Philippine Institute for Development Studies

Study on Public and Private Expenditures on Research and Development: An Integrative Report

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PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES
AND THE
DEPARTMENT OF BUDGET AND MANAGEMENT

STUDY ON PUBLIC AND PRIVATE EXPENDITURES ON RESEARCH AND DEVELOPMENT: AN INTEGRATIVE REPORT (FINAL REPORT)

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I. Introduction

This paper puts together key results and insights of the various papers written under the project "Study on Public and Private Expenditures on Research and Development". The Project is funded by the Department of Budget and Management (DBM) and the United Nations Development Programmes (UNDP). In particular, this paper integrates the following papers:

1. Technology Acquisition, Development and Dissemination in the Private Sector. 1998. By S. C. Halos

2. An Institutional Analysis of R&D Expenditures in the Public and Private Sectors. 1998. By E. E. Patalinghug

3. Identifying Areas of Support in Research and Development for the Manufacturing Sectors. 1998. By L. Nolasco

4. Consultative Workshop on R&D Expenditures: Proceedings. 1998. By PIDS Research Team

5. Private Sector Research and Development Activities. 1998. By T. Macapanpan

6. Philippine National Agricultural and Natural Resources Research System: Resource Allocation Issues and Directions for Reforms. 1998. By C.C. David, E.R. Ponce, S.C. Halos, and C.B Lamug

7. Rates of Return to R&D Investment in the Philippines. 1998. By C.B. Cororaton
8. Survey of Activities in Research and Development. 1998. By C.B. Cororaton, T.D. Caparas, R. Yacat, J. Cuenca, R. Casas, and M. Galvan

9. R&D Gaps in the Philippines. 1998. By C.B. Cororaton

10. Research and Development: A Review of Literature. 1998. By C.B. Cororaton

11. Research and Development in the Philippine Fisheries Sector, 1998. D.C. Israel

Furthermore, key results of related literature, which are of particular significance in the discussion, were also included. The papers are:

(a) Research Extension Linkage and the Philippine Agriculture and Fishery Research and Extension Systems. 1998. By E.R. Ponce

(b) Science and Technology Policy: Linking Industrial Strategy with Educational and Technological Development in chapter 4 of the book Promotion of Broad-Based Economic Growth in the Philippines, 1998. J. Sachs, et al.

(c) Streamlining the Science and Technology Sector for the Country's Development Goals. 1995. J. A. Magpantay

(d) Analysis of Policies and Factors Affecting Successful Commercialization of Technologies, 1991. V. B. Eclar

The R&D[1] study has a number of objectives. The important ones are:

(i) Conduct a survey on R&D activities of the public sector, in particular, R&D activities of government agencies and state universities and colleges (SUCs) from 1993 to 1996.

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[1]Based on the UNESCO definition, R&D is defined as any systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications. R&D activities include basic research, applied research, and experimental development. Basic research involves any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view. Applied Research encompasses any original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. Experimental Development comprises any systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products, and devices, to installing new processes, systems and services, and to improving substantially those already produced or installed.

(ii) Conduct a survey of literature regarding R&D expenditure patterns and institutional arrangements of other countries.

(iii) Conduct a survey of literature on the rates of return to R&D investments in other countries and estimate similar rates of return for the Philippine case. Compare the results with rates of return to other forms of investments.

(iv) Formulate a set of criteria/principles that can be used in allocating appropriate level of expenditure on R&D required for the country as a whole and in different sectors to enable achievement of the sector's development target.

(v) Determine unfilled R&D needs. Determine also the direction of gaps in R&D efforts in the different sectors and the appropriate role of government.

(vi) Recommend (a) sector prioritization of R&D expenditure, (b) more effective incentive arrangements to encourage greater private sector involvement, and (c) budgetary and other institutional arrangements which will increase the effectiveness and efficiency of government efforts in R&D.

This paper is divided into six major sections. The first section gives the introduction which emphasizes the objectives of the overall study on R&D. The second section gives a summary of the survey results conducted on R&D activities in the Philippines. It also points out the problem in the present statistical information and accounting system, and gives broad directions on how to improve it so that it can generate quick and accurate set of information related to R&D and S&T.

The third section gives a brief theoretical discussion on (a) the role of technology in economic growth and development; (b) the possible factors affecting productivity; and (c) the principle of congruence rule as a basis for allocating R&D resources into various competing productive sectors of the economy.

The fourth section discusses the patterns of R&D and S&T developments of selected countries, as well as of the Philippines. The discussion focuses on the world trends on R&D expenditure, R&D manpower, and corresponding levels of economic development of countries as measured either by GDP or GNP. It also surveys the rates of return to R&D investment in other countries, and presents comparable rates of return in the Philippines. The analysis on the rates of return focuses on agriculture and industry. Furthermore, the section gives a detailed description of the developments of the S&T systems in three countries: South Korea, Taiwan, and New Zealand. This is for purposes of setting up policy lessons, as well as of making comparison, for the Philippine case.

The fifth section discusses R&D gaps in the Philippines. The discussion focuses on productivity, as well as on the required R&D investments and R&D manpower at the national level. Furthermore, the discussion also includes sectoral level issues such as institutional weaknesses as a result of poor system, management and leadership, and policy lapses and failures.

The sixth section presents a number of recommendations in (I) R&D Investments; (II) R&D Manpower; (III) Incentive System; (IV) InstitutionalArrangement and S&T Coordination Mechanism; (V) R&D Delivery System; and (VI) Statistical Information and Accounting System.

II. Survey of Activities In Research and Development

A. Introduction

This section summarizes the results of the recent survey on R&D (Cororaton et al, 1998). As identified by a similar survey conducted by the Department of Science and Technology (DOST) in 1992, there are four major sectors which are doing R&D activities in the Philippines: (1) higher education (both private and state universities and colleges); (2) government agencies; (3) non-government organizations; and (4) private industry. The Philippine Institute for Development Studies (PIDS) was tasked to conduct a survey of only two of these major sectors, in particular, government agencies and state universities and colleges. The rest of the sectors are being covered by the ongoing survey of the National Statistics Office (NSO). The table below delineates the sectoral coverage of the R&D survey of PIDS-DBM and NSO-DOST.

Although PIDS covers only two major sectors, for purposes of coming up with initial estimates of the national R&D activities, attempts were made to estimate R&D activities of the other sectors. In particular, preliminary estimates have been

R&D Survey: Sectors and Survey Institutions

Sectors	Institutions Conducting the Survey
Higher education: • Private universities • State Universities & Colleges	• NSO – DOST • PIDS – DBM
calculated for private universities, private sectors, as well as for non-government organizations. **Government Agencies**	PIDS – DBM
Non-Government Organization	NSO – DOST
Private Industry	NSO – DOST

calculated for private universities, private sectors, as well as for non-government organizations. However, only broad totals have been calculated. In other words, the detailed breakdowns of the totals have not been computed because of lack of adequate information. A detailed discussion on the methodology used to estimate R&D activities of other sectors not covered in the present survey is discussed in Cororaton, et al 1998. However, it is important to highlight three relevant points:

(a) There were major SUCs which did not respond after frequent follow-ups. The UP system, for one, the largest among SUCs, did not respond even at the level of departments and R&D units. Frequent follow-ups were made directly to 21 R&D units in UP system. Since the UP system and other major SUCs contribute a major share to the total R&D activity, other sources of such as the R&D budget in the General Appropriations Act (GAA) were used to supplement the survey results. This increases significantly the R&D expenditures of SUCs. For example, for the year 1996, total survey showed R&D expenditure of P169 million. With information from the GAA, this increases to P409 million. However, this figure may still be understated, although only slightly, because information from the GAA do not include foreign sources of R&D funds. Moreover, estimates for the private schools were derived using fixed proportion (detailed methodology is in Cororaton, et al 1998).

(b) A comparison between the survey results and the actual expenditure of the DOST system as reported in the annual report was made. It was observed that there are huge discrepancies between the two. Further discussion on this is given in another section below. For purposes of coming up with preliminary estimates on R&D expenditures, the total derived from the survey results for the entire DOST system was replaced with the actual R&D expenditures sourced from the annual reports. Furthermore, there were those government agencies which did not respond to the survey even after frequent many follow-up. On top of this, it is so difficult to select among the budgeted expenditure items in the GAA for government agencies which are R&D-related. Thus, several assumptions were applied on some of the appropriate proportions to come up with the item called “adjustments” in the table (see Cororaton et al 1998). As a result, two preliminary sets of estimates were arrived at: one with adjustment and another one without adjustment. The discrepancy is huge, about a billion pesos.

(c) Estimates for non-government organizations, as well as for the private sector, were arrived at using their historical average share to total R&D expenditure over the period 1989-1992.

Two sets of estimates were arrived at using the above methodology. Estimates for 1996 with adjustments amounted to P3.4 billion, about 1.5 percent of GNP (see Table II.1). Estimates without adjustment amounted to only P2.4 billion, lower than the actual figure for 1992 of about P2.9 billion. For the unadjusted preliminary estimates, the average growth of total R&D expenditure over the period 1993-1996 is 16.5 percent. For the adjusted preliminary estimates, the average growth is 17.2 percent. There was less than 10 percent growth in 1994, but increased to around 20 percent in 1995 and 1996. Since inflation rate during this period was less than 10 percent, there was indeed a real increase in R&D expenditure especially in 1995 and 1996.

Table II.2 presents preliminary estimates of R&D manpower. These estimates were derived from the survey results, supplementary sources like the annual report of the DOST. Because of lack of undated information some assumptions were applied to estimate for those sectors which were included in the survey.

There are two types of R&D manpower categories: full time and part time. In terms of head count, the total full time R&D manpower in 1996 was 9,545. This represented an average annual increase of 8.2 percent over the 4-year period. In 1993, total R&D manpower was only 7,548.

Significant increases were also seen in part-time R&D manpower. In 1993 part-time R&D manpower was 4,131. In 1996 this increased to 5,698. The average annual increase over the period was 11.5 percent.

B. Presentation of Survey Results

Survey Population and Respondents. In the survey a total of 412 institutions were identified. Of the 412 institutions, 178 are government agencies (43.2 percent of the total), while the remaining 234 are state universities and colleges (SUCs) and government vocational and technical schools (VOCTECH), or 56.8 percent of the total survey population.

Of the total survey population, 210 institutions responded, or a response rate of 50.97 percent (see Table II.3). Of the 177 government agencies, 98 responded, or a response rate of 55.10 percent. Of the 234 SUCs and VOCTECH, 112 responded, or a response rate of 47.86 percent.

To have enough time for the preparation of information gathered for this report, July 25, 1998 was chosen to be the cut-off date. Survey questionnaires which arrived after this cut-off date were not included in the computation.

All respondents were sorted out into categories with R&D and without R&D activities. Of the 210 respondents, 69 are not engaged in any form of R&D activities. Of the 69 respondents without R&D, 26 are government agencies and 43 are SUCs and VOCTECH.

Survey Results. It should be noted that the discussion here is based on the answers directly provided to us by the different government agencies and SUCs through the survey questionnaires. *It does NOT take into account the adjustments done in Tables II.1 and II.2 wherein the survey results were supplemented with* *information from the GAA, actual expenditure of the DOST system based on the annual reports, and other assumptions discussed in the main report (Cororaton et al 1998).* Thus, only the sectoral totals under "survey results" items are consistent with the totals discussed here.

There are three levels of analysis in the tables and figures: (1) government agencies (also called agencies), (2) SUCs, and (3) all respondents - the total of (1) and (2). There are a number of interesting insights that can be observed from the detailed analysis of the specific items. Some of the relevant ones are:

(1) Although the levels of R&D expenditure of the respondents increased from 1993 to 1996, there was a deceleration in the growth from a high 19 percent increase in 1994 to just slightly over 10 percent increase in 1996. The deceleration was significant for government agencies in 1996 with a growth of only 8.4 percent. In the case of SUCs, the deceleration was pronounced in 1995 of only 3 percent growth from a growth of 11.4 percent in 1994. There was an improvement in 1996 with a growth of almost 20 percent.

(2) R&D activities are mostly focused on applied research. This is true for government agencies, as well as for SUCs. Experimental development also captures a sizeable share of R&D expenditure type.

(3) In terms of field of activity, agricultural sciences capture the largest share, followed by engineering and technology, natural sciences, and then social sciences. This is true for the total, as well as for both agencies and SUCs.

(4) In terms of sources of R&D funds, the largest share comes from the institution's own funds for R&D activities (which largely come from the government's appropriation for research and development). The share of the government (other than from the appropriation) also contributed a respectable share. Almost nothing comes from both foreign and private sources. These results manifest the very weak link between government owned-R&D institutions and the private sector.

(5) Almost 70 percent of R&D manpower are on full time basis; of which, more than 50 percent are male. This is true for both agencies and SUCs.

(6) In terms of types of R&D personnel, around 60 percent are in the category of scientists and engineers, both for full time and part-time. These scientists and engineers are mostly in agricultural sciences, social sciences and engineering and technology, both full time and part-time.

(7) For full-time R&D personnel, more than 60 percent have BS/BA degrees. A tiny portion has Ph.D. degrees and about 10 percent have MS/MA degrees. However, for part-timed R&D personnel, the educational level of the personnel dramatically changes. About 15 percent of the part-time personnel have Ph.D. degrees and 35 percent have MS/MA degrees. Only about 40 percent have BS/BA degrees. One reason that may explain this change is that R&D personnel with high educational attainment are doing part-time as well as consulting jobs which pay a lot better than full time jobs. Especially with wage standardization, there are no incentives for people who have advanced degrees to work for the government on full time basis.

(8) Full time R&D personnel with Ph.D. degrees are in social sciences (about 40 percent), agriculture sciences (35 percent) and natural sciences (20 percent). <u>Only about 5 percent are in engineering and technology</u>. On the other hand, part time R&D personnel with Ph.D. degrees are in agriculture sciences (35 percent), social sciences (25 percent), medical sciences (20 percent), humanities (15 percent). <u>Less than 5 percent are in engineering and technology</u>.

C. Information Gap on R&D and S&T Activities

Good and accurate analysis of R&D opportunities is one of the major factors that would help encourage private, as well as public, investment into R&D and S&T-related activities. This is because, normally, there are high risks involved in R&D investments (particularly the uncertainty in the outcome of an R&D undertaking), as well as there is high incidence of spillover or externality that is hard to appropriate. These uncertainties and other market failures can be minimized if the statistical information and accounting system is well established. A good information system leads to good analysis on the structure and nature of R&D activities. If there are significant market failures, with good analysis, then appropriate and correct policy measures can easily be formulated to correct these market kinks. However, the present statistical information and accounting system is extremely poor. It generates very inaccurate information of the variables of particular interest in policy. This assessment is based on the recent R&D survey conducted by PIDS (Cororaton, et al., 1998).

Few examples could indicate the extent of the problem:

(1) Results on the DOST System. Table II.4 shows R&D expenditure of the DOST system derived from the annual reports and the survey results. The survey generated a total R&D expenditure of P80 million in 1993. The actual total R&D expenditure based on the annual report amounted to P290 million, a huge discrepancy of about P210 million. In 1996, survey results indicated a total of P109 million, when in fact the actual expenditure based on the annual report was P510 million, again a big gap of P400 million.

(2) <u>Big Systems Unable to Respond</u>. One of the biggest R&D systems in the Philippines is the UP system. In the 1996 GAA, its budget amounted to P191 million. Omitting the UP system in the survey would clearly give an inaccurate set of information. The PIDS survey team made frequent follow-up with 21 different R&D units in the UP system, but still they were unable to respond. This is mainly because the existing survey questionnaire is entirely different from the structure of the accounting of the different institutions, not only of the UP system, but also of other SUCs and other government agencies. In such situation, one has to dig out old files to be able to answer the questionnaire. This takes a lot of time. As such, there is a big possibility that the institution may not be able to respond (which leads to low response rate), or, if it responds, it gives wrong and inaccurate set of information.

(3) <u>Variables Not too Relevant for Policy Analysis</u>. The usual questionnaire that is being fielded is UNESCO-DOST based questionnaire. It has sectoral breakdown that is totally different from the NSO-PSIC breakdown. As such, it is difficult to assess the effectiveness of R&D activities at the sectoral level using the standard analysis of relating sectoral output and productivity with the corresponding sectoral R&D activities.

Given these problems, there is an urgent need to overhaul the statistical information and accounting system on R&D and S&T activities. The first major step would include making the survey questionnaire consistent with the accounting system of the institutions so that information can be gathered quickly and accurately.

The next major step would involve reconciling the variables in the questionnaire consistent with the NSO-PSIC sectoral breakdown. The final step would entail institutionalizing the revised system in NSO because of its expertise in gathering information and its extensive nationwide network, so that regular information is generated.

III. Some Basic Economic Principles

This section discusses some basic principles regarding the role of technology in economic development, and the congruence rule as a basis for allocating budget for R&D. The first part involves a standard decomposition of output growth into factor inputs and technology, while the second one summarizes the major points raised in David et al (1998) on the congruence rule as an allocation mechanism; how can it be applied and what are its major weaknesses.

A. The Role of Technology in Economic Development

Consider a production function

(1) $Q = A(t) \cdot f(K,L)$

where Q is output, A(t) represents all that go into determining Q besides K, capital, and L, labor. Changes in A over time represent technical progress. Differentiating (1) with respect to time gives

(2) $dQ/dt = dA/dt \cdot f(K,L) + A \cdot df(K,L)/dt$

Equation (2) can also be written as

(3) $(dQ/dt)/Q = (dA/dt)/A + \partial f/\partial K \cdot K/f(K,L) \cdot (dK/dt)/K + \partial f/dL \cdot L/f(K,L) \cdot (dL/dt)/L$

(4) $G_Q = G_A + \partial f/\partial K \cdot K/f(K,L) \cdot G_K + \partial f/dL \cdot L/f(K,L) \cdot G_L$

where G_Q is growth in Q, G_A growth in A, G_K growth in K and G_L growth in L. However, $\partial f/\partial K \cdot K/f(K,L) = \partial Q/\partial K \cdot K/Q$ is the elasticity of output with respect to capital input, i.e., $e_{Q,K}$, and $\partial f/\partial L \cdot L/f(K,L) = \partial Q/\partial L \cdot L/Q$ is the elasticity of output with respect to labor input, i.e., $e_{Q,L}$. Therefore, the growth equation finally becomes

$$(5) \qquad G_Q = G_A + (e_{Q,K} \cdot G_K + \cdot e_{Q,L} G_L)$$

That is, growth can be decomposed into technological progress and the weighted sum of the growth in factor inputs, where the weights are the elasticities. There are a number of hypotheses which have been advanced by a number of economists on (5). One hypothesis argues that a growth strategy which focuses on factor accumulation, i.e., through G_K and G_L, is not sustainable in the long run because it will be subject to diminishing returns (Krugman, 1995). Another hypothesis states that A is *exogenous*, i.e., it is a drift parameter which is a function of time alone (Solow, 1956, among others). Another interesting hypothesis, and is particularly important in the present context, deals with the idea that A is *endogenous* - that it is a function of policy variables. Furthermore, it argues that factors affecting A have increasing returns (Romer 1986, 1990, Lucas, 1988, and Robelo, 1991). For example, improvements in the educational system increase the quality of labor, which in turn prevents any diminishing returns from occurring in physical capital.

To allow for the fact that some of the productive units are not operating along the production frontier, G_A, or TFP, is further decomposed into two sets of factors: technical efficiency and technical progress. Technical efficiency is a movement towards the production frontier. This movement is largely due to improvements in organization, management, and implementation of proper systems and programs. On the other hand, technical progress is an upward shift in the entire frontier. This shift is mainly attributed to new developments in technology, in the form of new production processes, or acquisition of foreign technology and innovation. For sure, R&D is one of the factors that affect this shift in the frontier. R&D could either be in the form of an increase in R&D investments or in the supply of R&D manpower. Both of these factors increase the absorptive capacity of the production units to new technological developments and knowledge available in the environment. Another factor that affects the shift is proper incentives. Among the most important incentives are macroeconomic stability, trade openness, and minimum market distortions.

There are empirical studies which looked into the determinants of TFP. Fischer (1993), for example, did a cross-country study involving a large group of developing countries investigating the role of macroeconomic factors in growth and productivity. One of his major conclusions is that large budget deficits are associated with lower growth, and therefore lower productivity. "Most of the results suggest also that these relationship are to some extent causal. The positive association between the budget surplus and growth appears particularly robust..." This is interesting because normally developing countries suffering from large budget deficit are highly unstable. Economic instability therefore negatively impacts productivity performance. Economic stabilization therefore plays a major role in improving productivity performance.

In the Philippines, two studies attempted to conduct regression analysis to examine some possible determinants of TFP in the Philippines: Austria (1997) and Cororaton and Abdula (1997). The first study considered TFP of the entire economy as the dependent variable in the regression, while the second TFP of the manufacturing sector.

In Austria's paper, TFP of the entire economy was regressed against trade and investment policy indicators. The indicators include tariff rates, share of exports to GDP, share of imports to GDP, foreign direct investments (FDI), and inflation. Both tariff and import shares are used to capture the trade liberalization program of the government through the reduction in tariff and non-tariff barriers. FDI is one of the major vehicles for transferring technology from abroad, thus its inclusion in the analysis would attempt to capture transfer of technology. Inflation is a “catch-all” indicator of economic instability. High inflation means macroeconomic instability. Normally, economic instability discourages productivity-enhancing programs from being adopted (like R&D) and investment.

The regression results show a statistically significant effect of exports on TFP growth (Table III.1). The two major exports of the Philippines are garments and semi-conductors which account more than 60 percent of total merchandise exports. These exports are highly import dependent in terms of raw materials and technology. In fact, these exports are closely tied up with the foreigner buyers through consignment. Thus, the growth in exports could also be a vehicle of technology transfer.

Contrary to the general expectation, imports have a negative effect on TFP. According to Austria (1997), there are two possible explanations for this. First, in the regression, total imports were considered. Imports of machinery and equipment, which usually embody new production techniques and technology, are only a fraction of the total. Thus, the inclusion of the total imports might have captured other effects also. Second, unavailability of skilled workers who can adequately operate the new machines and equipment might have led to their inefficient use, thus causing lower productivity.

Tariff rate has a negative effect on TFP, although the coefficient is not statistically significant. Effective rate of protection (EPR) could have been the more appropriate indicator of tariff liberalization, but time series on EPR is not available. However, Austria (1997) cited other studies which showed that when protection is reduced at a moderate rate, the rise in productivity is highest; and when protection is reduced at an excessively fast rate or when it is not reduced at all, the rise in productivity is lowest.

Foreign direct investments (FDI) have positive effect in one of the estimated equations but are not statistically significant (Equation 1 in Table III.2). While it may take some time before FDI brings about productivity effects, the result of incorporating a one-year lag in FDI yields a positive effect, (Equation 2). However, the effect of including both total FDI and FDI in manufacturing shows a significant positive effect of total FDI on TFP growth, but a significant negative effect of FDI in manufacturing (Equation 3). Austria (1997) attempted to explain the negative effect of manufacturing FDI by citing the fact that multinational companies are oriented towards the global market, thus, there may be less room for adaptation of technology to the local economy in a wide scale manner.

Lastly, inflation, which is a catch-all variable of macroeconomic instability, has a significant negative effect on TFP.

In a similar exercise, Cororaton and Abdula (1997) conducted a regression analyzing some possible factors affecting manufacturing TFP. The factors included in the analysis were: estimated TFP of the manufacturing sector, exports, imports, tariff, minimum wages, R&D, foreign direct investment and inflation. The variables entered the analysis either as ratios to GDP or in first difference or both.

All estimated coefficients are statistically significant (see Table III.3). Exports ratio is positively affecting TFP of manufacturing. The reason discussed above with regard to export may also apply here, i.e., exports could be one channel through

Table III.2. Determinants of Total Factor Productivity, 1960-1996

Dependent Variable: TFP Growth of Philippine Economy	Equation (1)	Equation (2)	Equation (3)
Constant	-0.016 (-0.69)	-0.018 (-0.76)	0.034 (0.53)
Share of Exports to GDP	0.005 (3.41)*	0.005 (3.31)*	0.008 (2.41)**
Share of Imports to GDP	-0.003 (-2.27)**	-0.002 (-1.99)***	-0.004 (-3.46)*
Tariff rate	-0.83E-0.4 (-0.07)	-0.015E-03 (-0.13)	-0.002 (-0.99)
Inflation rate	-0.002 (-4.62)*	-0.002 (-4.91)*	-0.002 (-5.46)*
Foreign Direct Investment (FDI)	0.12E-05 (1.26)		0.33E-05 (2.14)
FDI_{t-1}		0.11E-05 (1.01)	
FDI in Manufacturing			-0.11E-05 (-1.85)**
DW Statistics Adjusted R^2	1.94 0.53	1.89 0.52	2.09 0.67

Note: t-values are in ( ). *, **, and *** indicate significance at 1, 5, 10 percent levels, respectively.
Source: Austria (1997).

which foreign technology is transferred to the local economy. This is because of the close tie-up of the major exporters in the Philippines with the foreign direct buyers. However, similar to the previous results, the same negative effect of imports on TFP manufacturing is seen in the result.[2]

Tariff has negative effects on manufacturing TFP. This would imply that a reduction in the tariff protection would result in productivity improvement (probably due to efficiency gain from a competitive environment). FDI has a significant positive effect on TFP.

[2] The negative coefficient showed up when capital imports was included in the regression instead of total imports. Although the reason behind this may be unclear, the authors would attribute this to the inapproriateness of technology adopted by industries. Such technology which functions merely as inputs, entails no significant effect on domestic science and technology (Yap, 1989).

Minimum wage, usually wage rate for unskilled labor, in the Philippines is legislated. The results show that an increase in minimum real wage decreases productivity, which is generally expected. Usually, a wage system which is not based on productivity is inefficient. Inflation, an indicator of economic instability, negatively affects productivity. High inflation occurs in an economic system with lots of uncertainty. This prevents organization from pursuing productivity-enhancing programs.

R&D as a percent of GDP has a positive effect on TFP. This has an important policy implication because, usually, technological change cannot be realized without technological infrastructure. Furthermore, the effectiveness of technology transfer requires distinct activities and investments, and a certain level of technological development in the country to minimize the cost of implementing the new technology and to maximize its productivity once in place. Normally, the technological development of a country depends upon R&D investments and on the efficiency of its R&D institutional system.

Furthermore, a number of convincing TFP growth can significantly affect economic. In other words, these studies suggest that cross-country growth is due to differences in TFP growth. For example, Klenow and Rodriguez-Clare (1997) calculated that 91 percent of the cross-country differences in growth rates were due to differences in TFP growth. The papers of King and Spiegel (1997), Nehru and Dhareshwar (1993), Benhabib and Spiegel (1997), and Bosworth and Collins (1997) all support that idea of the significance of TFP in economic growth.

B. Congruence Rule

The discussion on congruence rule is based on David et al (1998). They argue that research resources should not be simply allocated to research program areas (RPAs) ranked from highest to lowest net social benefits until the total budget is exhausted. In particular, this allocation rule "will not necessarily maximize the overall net present value (NPV) per unit of research investment because the programs are presented as discrete alternatives and some reallocation of resources among the programs might lead to an increase in the overall NPV". Ideally, the optimal resource allocation may be determined through a mathematical programming. However, this is difficult to compute because of huge information requirements since the net social

Table III.3. Determinants of TFP Growth in Manufacturing

Dependent Variable: TFP Growth of Manufacturing	**Results: Coefficients and Test of Significance**
Constant	5.316 (27.267)
Exports(-1)	0.148 (8.581)
Imports(-1)	-0.519 (-18.522)
D(Tariff)	-1.740 (-33.438)
Wage	-0.126 (-9.353)
DRD(-1)	0.101 (9.353)
FDI(-2)	0.005 (-14.081)
INF	-0.153 (-14.081)
INF(-1)	-0.468 (-23.088)
Adjusted R2 = 0.997 DW = 0.65 F-Stat = 448.63	**D(tariff):** period differential of average nominal tariff rates **Wage:** growth of research and development expenditure as % of GDP, lagged one period
Where: **Exports(-1)**: real growth of exports, lagged one period **Imports(-1)**: real growth of imports, lagged one period	**FDI(-2):** foreign direct investment **INF:** inflation **INF(-1):** Inflation, lagged one period

Source: Cororaton and Abdula (1997)

t-values are in ( ).

benefits at alternative levels of research investments will have to be estimated. Given the extremely poor information on R&D and S&T in the country, this may not be feasible.

Conceptually, when the marginal social benefits of a research investment equal the marginal cost of research across RPAs, the total net present value of given research investment is maximized. Because of severe data limitations, however, simplified assumptions have to be applied to derive some decision rules For example, if the marginal costs of research or the price of research resources is equal across RPAs, then the optimal research allocation may be derived by setting marginal value products equal to each other. "This is the *congruence rule* where the optimal research resource allocation across commodity program areas will be *proportional* to the respective commodity value added or value of production shares. In other words, given a total budget for research, the intensity ratio, i.e., research expenditure as a ratio of the value added contribution should be equal across commodity research program areas."

The congruence rule is not generic. It may not be applicable to all resource allocation problems. Some of its limitations are:

(1) It cannot be used to allocate research resources to research issues, such as policy, institutional, and other socio-economic research, natural resource management, food safety, nutrition, and etc.

(2) It cannot be used to allocate research resources between public and private research, nor the choice between importing or locally developing new technologies.

(3) "It does not consider potential change in comparative advantage arising from factor and product market changes."

(4) "It does not consider possible differences in scientific potentials for research success, probable adoption patterns, and other cost factors of research, such as discount rates, timing of research benefits and costs, and economies of scale and scope."

IV. Patterns, Developments, and Policies: General Experiences on R&D and Technology of Selected Countries and the Philippines

A. General Experience

The common indicators of R&D patterns are R&D expenditure as a percent of gross national product (GNP) and R&D manpower as measured by the number of scientists and engineers relative to population. These indicators are shown in Figures IV.1 to IV.2 for different countries at their respective levels of economic development. One can observe that high-income countries have generally high R&D levels both in terms of expenditure and manpower. There are strong and convincing empirical evidences that show that R&D activities propel and sustain long term economic growth. In particular, R&D activities create technological innovation, which in turn leads to productivity increases and, finally, to economic growth and prosperity.

Generally, R&D investments have high returns. Although estimation techniques used in computing for the rates of return to R&D investment are far from perfect mainly because of data problems, the estimated rates of return found in the literature for both developed and developing countries, and for both agriculture and industry, are encouragingly high. Evenson and Westphal (1995) surveyed the results of 156 studies estimating rates of return to R&D investments in agriculture and 40 studies in industries. They found that, indeed, the rates are very high, even higher than other forms of investment like basic infrastructure.

Table IV.1 shows that of the public agricultural research, more than half of the results of the studies surveyed show rates of return higher than 50 percent. Only few studies show estimated rates of return lower than 10 percent. Furthermore, in terms of the distribution of estimated returns, developing countries have higher estimated rates compared to developed countries. However, there are relatively fewer studies reporting rates of return to private sector R&D used in agriculture, but again the estimated rates of return are also high.

One of the major reasons behind the high rates of return to developing countries' R&D in agriculture is the spillover effect from developed country research. "Indeed, LDC systems, in concentrating on adaptive invention, do rely on the international agricultural research centers and developed country systems for pioneering invention and pre-technology science." (Evenson and Westphal, 1995).

Another set of empirical evidences is found in the study of Librero (1997) which surveyed studies on rates of return to investment in agricultural research for selected countries and commodities. Table IV.2 presents the results. It shows the same pattern of high estimates for rates of return. In the Philippines, estimated rates of return are particularly high for sugarcane, mango, and poultry.

Similarly, recent results of Cororaton (1998) portray the same picture of high return to agriculture R&D investment. In particular, the estimated rates of return to R&D investment in the primary sector, which includes agriculture and mining industries, are high, averaging between 54 and 60 percent.

On the other hand, few studies have estimated returns to industrial R&D in developing countries. This is because it is generally difficult to measure directly the overall volume of technological effort related to technological change in the industrial sector. What is usually done is to infer the rates of return from estimates of productivity growth. There are limited estimates that indicate similarly high rates of return to industrial R&D investments. Among the possible reasons for these high returns to R&D investments is the achievement of efficiency gains as a result of R&D. In most developing countries, firms operate below the local production frontier or even further behind the frontier of international best practice. As firms pursue R&D and adopt newer available technologies, they move up fast towards the frontier, thereby realizing high returns from R&D investments. Another possible reason for the high rates of return to industrial R&D is the spillover effects of R&D results across different sectors and industries, including agriculture. Griliches (1991) and Nadiri (1993) have looked into a number of empirical estimates and found that R&D spillovers are of substantial importance and suggests that the social returns are considerably higher than private returns.

In the Philippines, there are few empirical evidences on the rates of return to industrial R&D. The studies conducted by Pack (1987, 1990), which focused on the computed potential returns from productivity-enhancing expenditures on adaptive modifications and skills development in a sample of Philippine textile firms, indicate that more than 80 percent of the firms in the industry would realize higher returns from such expenditures than from alternative investments. However, the studies of

Cororaton (1998) and Cororaton and Abdula (1997) show relatively lower rate of return to industrial R&D investment. The former shows rates of return ranging from 10 to 12 percent, while the latter about 10 percent.

The cross-country analysis of Cororaton (1998), which relates TFP growth of countries with their respective indicators of R&D levels, also provides another set of evidence indicating high returns to R&D investment. These are shown in Figures IV.3 and IV.4. The figures show the partial effects R&D spending and R&D manpower on productivity. One can observe that TFP increases faster at higher ratios for both R&D expenditure and R&D manpower. This would indicate increasing returns to investment in technology, R&D, innovation and other knowledge-based activities, which are generally consistent with the conclusion of Evenson and Westphal (1995) on high rates of return to R&D investment.

Another important trend in R&D expenditure is presented in Figure IV.5 which shows the expenditure pattern of government and the private sector. Based on the data of countries with different levels of economic development in the East Asian Region, one can observe that the private sector plays a very important and significant role in R&D activities as a country progresses. For example, economically progressive, as well as R&D aggressive countries, such as Japan, South Korea, Singapore, Taiwan, Hongkong and Malaysia, have high private sector R&D spending relative to government spending. South Korea, in particular, has an expenditure structure in R&D consisting of 80 percent private and 20 percent government. The same is true for Japan. However, for countries with lower level of economic development such as the Philippines, Thailand, and Indonesia; the government sector plays a dominant role in R&D activities as shown by their respective structure of R&D expenditure. In the Philippines, for example, R&D activities are mostly done by the government sector.

There are factors behind such differences in the patterns of R&D investment between government and the private sector. Some of these factors involve the existence and effectiveness of institutions, and the effectiveness of market safeguards in cases of market failures. Although, as shown above, returns to R&D investments are generally high, a host of factors prevent the private sector from investing in such activities. In the literature, the common deterrent factors include: pervasiveness of knowledge spillovers and the problem of appropriability of R&D outcomes, credit constraints faced by research organization/institutions, and the contractual incompleteness induced by the impossibility of describing in advance the characteristics of innovation developed. All these factors have mutually reinforcing effects of discouraging and preventing R&D investments, as well as of diffusing developed knowledge to future potential innovators. Because of these imperfections, the government, through public intervention, has a major role in ironing out these market kinks. The usual government interventions include granting of subsidies to organizations/institutions doing R&D activities, and allocating and enforcing property rights to innovations. However, while government intervention is clear, the form of intervention the government should take is totally vague and unclear. It is highly controversial among policy makers, resulting in so much debates. Although the debate process is good in a democratic system, the cost of delay in implementation of policies could be tremendous. Among the key issues being debated are: "Should public intervention be centralized or decentralized? Should it emphasize the provision of R&D subsidies or instead should it confine itself to the design and enforcement of patent legislation? Should R&D subsidies be targeted to particular sectors, industries, or firms, or instead should R&D subsidies be provided on a non-discriminatory basis? Should public financial participation in R&D investments take the form of direct subsidies (e.g., tax subsidies or government transfers) or should it, instead, involve the government's participation as a creditor and/or as a shareholder?

B. Selected Country Experiences: Technology Structure and Policies.

This section looks into the experiences on R&D and technology development of selected countries in the hope of getting lessons for policy in the Philippines. The countries covered are South Korea, Taiwan, and New Zealand.

South Korea[3]

One of the countries, which adopted successfully an aggressive policy on R&D, is South Korea. In South Korea, S&T development strategy went through several different phases to make it attune to the changing national development objectives and strategies, as well as to the changing economic environment. R&D and S&T policies have constantly been adjusted to meet economic and social

[3] A more detailed discussion is seen in "Research and Development: A Review of Literature" . Part of the discussion here was taken from that literature.

development needs of the country throughout its economic growth and industrialization. Tables IV.3 and IV.4 outline briefly the progress in the economy and the S&T development and industrial technology that accompanied the economic progress.

The main goal of development in the 1960s was to develop the basic industries for import substitution. Thus, the following industries were actively supported: fertilizer, cement, oil refinery and steel. During the same period, export-oriented light industries were vigorously encouraged. However, at that particular period, technological capability that would support such development strategy was not available. To remedy the problem, strong emphasis in the field of S&T was placed on the importation of technologies needed to build up the basic and light industries.

The policy formulation in Korea was dynamic. While the importation of needed technology was going on, the government actively pursued a policy of building up technology capability through the setting up of S&T infrastructure such as technological training and education. Thus, as the starting point of the institutionalization of R&D/S&T for industrial technology, the Korea Institute of Science and Technology (KIST) was established in 1966. As a first major move to develop the badly needed technological capability, the KIST recruited hundreds of qualified Korean scientists and engineers working abroad through the government support and incentive system.

To establish and strengthen the institutional framework, the Ministry of Science and Technology (MOST) was created in 1967 as the central government agency looking into the development of R&D/S&T (Table IV.5). Furthermore, at about the same period the S&T Promotion Law was enacted to provide the legal basis for S&T development. Under this institutional framework, the first major task was the training of skilled workers and craftsmen. Thus, vocational education and training programs were launched on critical technical fields needed both by the public and private sectors. Furthermore, industrial firms were encouraged to conduct in-plant-training programs with government support.

The direction of economic policies moved towards the development of heavy and chemical industries through the absorption of imported technology in the 1970s. During the period, policy emphasis was on fostering more technology-intensive industries. To facilitate this, serious effort was made to improve imported and existing technologies and to meet the ever-increasing needs of scientists and engineers. Thus, assimilation of imported technology in the private sector was encouraged aggressively. Technical personnel who were trained at the technology-supplier firms played an important role also in the process of technology assimilation. Technologies were assimilated in order to better adapt to local conditions and therefore to reduce production costs. Government support and backing were very visible in all the effort and initiative to develop, adopt and assimilate foreign technology, especially during the initial phases when the industry was first reluctant to venture into in-house R&D because of high-risks involved and limited financial resources to carry on the R&D activities. In fact, to further support the assimilation process, a dozen of other government-supported R&D institutes were established specializing in the area of machinery, electricity, electronics and telecommunication, chemistry, and shipbuilding.

S&T education at the college level was strengthened and expanded in order to meet the increasing demand for college graduates and to increase its level of technical manpower and facilitate the process of industrialization. In line with this objective, the government drastically expanded college and graduate level education. It placed special emphasis on such fields as chemical, mechanical, electrical and electronics engineering. The S&T education system was further given a boost by the recruitment of qualified faculty members from abroad and by the financial support to significantly expand the educational facilities. In particular, in 1970, the government opened a new graduate school, the Korea Advanced Institute of Science and technology (KAIST), with a special mandate to train leading scientists and engineers.

In the 1980s, in an effort to solve the social problems which had been neglected during the period of rapid economic growth development, policy directions in Korea moved towards socio-economic development. Thus, the government started reducing the intervention in economic activities and began minimizing the measures that protected domestic industries from foreign competition to enhance the competitiveness of industries. During the same period, S&T policy started emphasizing in the localization of key strategic high technologies, and in the development of high caliber S&T manpower and in the promotion of private sector R&D capabilities. In fact, the government formally launched the National R&D project in 1982 to aggressively push for the localization of key industries. This initiative was financed by both the government and the private industries and was put to a clear focus on developing key strategic technologies which normally could not be pursued by the industry alone. With this and the government's encouragement and support, the private sector took the "driver's seat", so to speak, in R&D activities through their own R&D institutes.

The active participation of the private sector in R&D has been the key element in the development process in Korea. Under the Industrial Technology Development Promotion, the private sector has been provided with enough incentive to participate in R&D. The incentives include tax privileges and financial support such as tax deduction and tariff exemption on R&D reserve funds and subsidies, R&D equipment and facilities, human resource development expenditures (Table IV.6). As a result the number of private firms with R&D capability to do research increased drastically. In fact, at present the private takes a dominant role in R&D activities (Table IV.7).

Even with the increased participation of the private sector in R&D, the government continues to upgrade and improve the existing R&D/S&T infrastructure. This improvement focuses on two major areas: manpower development (Table IV.8 for details); and S&T information system and network. The latter strengthens the information system including S&T data collection, application and distribution. It also includes intensifying the information highway network in order to facilitate the rapid transmission of S&T information to the end-users and to fortify the foreign technology information collection through associate institutions abroad.

This infrastructure build-up comes about because of increased investment in R&D. The emphasis on technology development and R&D will continue to be so in the future with the expected expansion of R&D investment from 2.1 percent of GNP to 4 percent in 1996 and 5 percent in 2001, along with the expected increase in the S&T manpower from 15.6 persons per 10,000 population in 1990 to 23.5 in 1996 and 30 in 2001.

Technology Policies in Taiwan[4]

The technology development strategy adopted in Taiwan is one that is strongly encouraging private sector participation. This can be observed from the technology policies pursued, which can be grouped into three categories: supply side, demand side and environment side. In the supply side, the government directly influences the technology supply through the provision of financial resources, manpower assistance and technical assistance. In the demand side, the government affects the technology sector through the provision of stable market for contract research and through the use of government procurement programs to guide the direction of technological development. In the environment side, the government creates a favorable economic climate in order to indirectly affect the behavior of the firms in terms of their R&D activities. Their behavior can be affected through tax incentives, patent protection and other regulations.

The government, through its Industrial Development Bureau (IDB), developed what is called the "Targeted Leading Product" (TLP). Firms, which develop, produce and market products included in the TLP list, will receive various government support and incentives. Products will be considered Targeted Leading Products if they meet the following criteria:

(a) The product is in a newly developed, high-tech industry (such as communications, aerospace, advanced materials, semiconductors, etc.).

(b) The technology necessary for the development of the product exceeds the existing level of technical expertise in the domestic industry.

(c) The product has high market potential, and has the capability of stimulating the development of related industries.

Supply-Side**.** There are three types of supply-side policies adopted to encourage R&D activities in firms which produce products that belong to the list of Targeted Leading Products: (i) financial support; (ii) manpower assistance; and (iii) technical assistance.

The financial support of the government to qualified firms are in two forms: financial subsidies and loans. According to the regulations governing the implementation of the Targeted Leading Products, 50 percent of the development

[4] A more detailed discussion is seen in "Research and Development: A Review of Literature".

funds required for the targeted leading product development plans which have been approved will be put up by the government. In addition, the other 50 percent financial requirement will be extended in the form of a loan under IDB's Matching Funds Program (MFP). However, the firms which have received the financial assistance through MFP are obligated to pay back the loan after the product has been on the market for one year. In addition, the firms are required to pay royalties of 1-4 percent (in most cases 1 percent) of annual product sales for up to three years.

In terms of manpower assistance, the Ministry of Economic Affairs (MOEA) established universities and non-profit organizations which train manpower for research. However, because of high demand for R&D staff, the system could not cope up. This created a shortage. Furthermore, Taiwan's educational system focuses on the cultivation of teachers and professors. The training of technical research manpower has given relatively less emphasis. Thus, in the light of these shortages in the supply of technical research manpower, adjustments would have to be done, such as coordinating the educational planning with research manpower demands, and encouraging cooperative research and efforts in research manpower cultivation.

In terms of technical assistance, government support can be classified into two types: (i) technical consulting services to local firms which are upgrading their production technologies; and (ii) transfer of key technologies developed in the state-owned research institutes (e.g., the Industrial Technology Research Institute (ITRI) and the Information Industry Institute (III)) to the industrial sector.

ITRI, which was created by the government in 1973, has been an important channel for government intervention in R&D. In fact, more than 60 percent of the Science and Technology Research Project, which has an annual budget of over NT$10 billion, is under the purview of ITRI. Furthermore, ITRI has been quite involved in several cooperative research projects with private firms. Cooperative research can allow local firms to send their personnel to ITRI right from the beginning of the joint research project. This type of cooperative arrangement facilitates the technology transfer and therefore bridges the gap between ITRI and the private sector on what technologies that should be developed. In other words, through cooperative research the government facilitates its technical assistance to the private sector.

The discussion in this section is largely based on the said literature.

Demand-Side. There are two ways by which the government can support technology development through the demand side in Taiwan: public procurement and contract research. However, not much details are available on contract research. What is discussed here is only the public procurement.

There are high risks involved in R&D activities, especially in the early stages of the product development. In public procurement the government provides a guaranteed contract to purchase new or strategic products developed by the private firms in Taiwan. Thus, through this guarantee, it provides a stable market demand for R&D products, and therefore greatly reduces uncertainty, especially in the early stages. By minimizing the uncertainty, the public procurement provides incentives to local firms to engage activity in R&D investment.

In Taiwan at present, laws and regulations related to public procurement include the "Administrative Law of Public Enterprises", as well as the laws defining the procedures for imports. However, there are indications pointing to the fact that there are some problems in terms of effective and adequate enforcement of these regulations. In advanced countries, public procurement policy has been effectively used to enhance long-term competitiveness for certain industries.

Environment-side. Here the government attempts to create an environment that is conducive to R&D investment through innovation-oriented regulations and tax incentive schemes. A number of regulations have been pursued. The more important ones include the Fair Trade law which encourages a fair, competitive environment. This encourages small and medium enterprises to get engaged more in R&D investment. Patents, protection of royalties and intellectual property rights (IPR) have also been enforced to safeguard the private sector in their R&D activities. Some of the IPR laws include the copyright law, the cable TV law and the industrial design law.

Furthermore, to encourage and stimulate R&D investment and technological upgrading, the government formulated the "Statute for Industrial Upgrading and Promotion" (SIUP). Enacted in 1991, through this SIUP, the government implemented R&D promotional policies such as R&D tax credits[5], accelerated depreciation of equipment and exemption from tariffs.

The Science System in New Zealand[6]

Prior to the reforms, the science system in New Zealand was dominated by a small number of large government departments with mixed and overlapping roles. The government, on an institution-by-institution basis, directly funded the departments. With the onset of the recent reforms, the entire system was reorganized into a system with three separate, independently run, and highly focused major components. The three components are (i) technology policy; (ii) science funding; and (iii) science operations (see Figure IV.6). The separation of these components enabled clearer objectives to be established at all levels in the science system. The separation also allows each component to focus on its own set of activities and therefore creates a better system of accountability.

<u>Policy Making on Technology</u>. Although the present science system has three separate components, the overall policy making body regarding science and technology matters in New Zealand is still the Government. Broad directions are based on the recommendations to the Cabinet of a Cabinet Committee. The members of this committee, however, are not permanent, but could change from time to time. Presently, there are three ministerial portfolios in the government with specific responsibilities for research, science and technology. These are the (i) Research, Science and Technology (RS&T), (ii) Education and (iii) Crown Research Institutes.

<u>Policy Advice</u>. RS&T's main responsibilities include:

(a) giving of S&T policy advice, including advice on science priorities and funding, to the Ministry of Research and Technology;

(b) gathering and disseminating of statistics and descriptive information on research, science and technology and for administering international science relations at a government-to-government level;

[5]In the R&D tax credit scheme, firms with at least NT$3million dollars worth of investment in R&D in one year are eligible for 15 percent credit. Firms spending more than NT$3 million and with R&D intensity (measured as the ratio of R&D spending to sales) of 3 percent are eligible for incremental credit at 20 percent on the amount exceeding NT$3 million.

(c) providing a consultative form on issues and policy proposals in research, science and technology

In addition to these, it also acts as the agent of the Minister of Research in the overall administration and monitoring of public investment in science and technology.

Funding. In 1990, the Foundation for Research, Science and Technology (FRST) was created as an independent statutory authority. FRST's main function involves funds allocation to research and development and scientific services which fall within the definition of public good science and technology. Other funding agencies include: (i) Health Research Council - the main financier for health research; (ii) Animal Health Board – the one that funds research on the study of epidemiology of TB, as well as new toxins and their application; and lastly, (iii) Agricultural and Marketing Research and Development Trust which funds research activities on agriculture, pastoral, horticultural and forestry industries.

Science Operations. In 1992, the different department carrying out research projects were reorganized and restructured to enable their research activities to be continued in newly formed government-owned companies, or Crown Research Institutes (CRIs). The structure of CRI provides a more open and flexible management of science. It creates avenues for better collaboration between the public and private sectors in the fields of research and development, as well as in the transfer of technology. Furthermore, the company structure of the CRIs provides full commercial powers. The structure also allows access to funds through borrowings, and permits joint ventures. The structure also allows to form subsidiary companies so that the CRIs can fully exploit the commercial potential of new development in the country.

Although separated, the CRIs are closely linked to the science web, local as well as international. Their science operations are linked with Universities, Polytechnics, other government departments, and research associations and research organizations with similar activities.

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[6]. This section is largely based on "Research and Development: A Review of Literature".

C. **Philippine Experience**.

Cororaton (1998) surveyed UNESCO-based data on R&D indicators for 91 countries and found that the Philippines ranks very low in terms of R&D effort. Table IV.9 shows that out of 91 countries the Philippines is at the 73rd place in terms of the number of scientists and engineers per million population. It has only 152 scientists and engineers per million population. This is far below the maximum of 6,736 scientists and engineers per million population. In terms of R&D expenditure to GNP ratio, the Philippines is at the 60th place with a ratio of 0.2 percent in 1992. This is far below the maximum of 3 percent.

The low number of scientists and engineers is reflective of the general tendency of the educational system in the Philippines to produce non-technical graduates. Table IV.10 shows that while the Philippine educational system produces a very high number of tertiary graduates, the post-baccalaureate science and engineering students as a percent of post-baccalaureate students is very low. In column 6 of the table, the Philippines ranks the lowest in the list with a ratio of only 8.65. This is far from the second lowest of 20.76 percent, which is for New Zealand. The highest is China with a ratio of 74.26 percent.

There is in fact a dilemma in the present educational system because of the educational “mismatch”. While there is a great demand for technical and engineering-related graduates by local industries, private tertiary schools continue to produce non-technical graduates. This is, indeed, a big policy area problem. One of the factors that would explain this is that private schools prefer not to go into these technical-related courses because of their high laboratory requirement that is capital intensive. Non-technical courses are less laboratory intensive and therefore less capital intensive.

Furthermore, in a recent survey conducted by the Philippine Institute for Development Studies (Cororaton et al, 1998) on R&D activities of government agencies and state universities and colleges (SUCs), it was observed that more than 40 percent of R&D personnel with Ph.D. degrees are in social sciences, while only less than 10 percent are in engineering and technology (Figures IV.7 and IV.8). About 35 percent are in agriculture-related sectors.

S&T Policies and R&D Programs. Philippine S&T has a long history. It can be traced back to the early American colonial period with the creation of the Bureau of Science. The American government, through this Bureau, formed the Philippine S&T. However, the coverage was very limited. It mainly focused on agriculture, health and food processing. Thus, because of the colonial economic policy, the development of industrial technology was largely neglected.

Moreover, the public school system was created at about the same period. Through the creation of the University of the Philippines (UP) system and the various S&T-related agencies and laboratories, the Bureau became effectively the training ground for Filipino scientists.

Major shifts in the direction of Philippine S&T took place right after the proclamation of independence in 1946. It was reorganized into an Institute of Science and was put under the Office of the President of the Philippines. Despite these changes the real effects in terms of its impact on the economy were marginal. The Institute suffered from lack of support, planning, and coordination. In fact, in the Bell Mission's Recommendation, it was mentioned that the Institute had no capability to support S&T development because of the lack of basic information, neglect of experimentation and small budget for R&D activities.

There were also major shifts in the 1950s and 1960s which focused on S&T institutional capacity-building. This was done through the establishment of infrastructure-support facilities like new research agencies and manpower development. Again, the effects were not significant. The usual problems of lack of coordination and planning, especially technology planning, prevented the system from performing effectively its functions. This was manifested in the unplanned activities of the researchers within the agencies. Most areas of research were left to the researchers for them to define under the presumption that they were attuned to the interests of the country. They were expected to look for technologies and scientific breakthroughs with good commercialization potential. Without clear research directions, researches were done for their own sake, leaving to chance the commercialization of the output.

In response to these problems and to the need for S&T to generate products and processes that are supposed to have greater beneficial impact on the country, focus was re-directed towards applied research in the 1970s. Furthermore, in the

1980s, research utilization was given stronger emphasis. This led to the reorganization of the NSCB into the National Science and Technology Authority (NSTA) in 1982. One rationale for NSCB's reorganization was the need for an effective and efficient utilization of the results of R&D activities through greater commercialization of outputs. A significant innovation under the reorganization of the NSTA was the creation of the S&T Council System, where an S&T council became responsible for the sectoral formulation of policy and strategies for its specific field and allocation of funds. There were 4 councils under the system: PCHRD, PCIERD, PACRRD and NRCP (Table IV.11 for the exact names of the councils and institutes of the DOST). Later NRCP was replaced by PCAMRD and PCASTRD. Furthermore, the NSTA had 8 research and development institutes and support agencies under it. In the mid-1980s, regional offices for S&T promotion and extension were established to further hasten the development of S&T. There was also a conscious effort to assist and encourage creative local inventors through institution building and support measures. A national center for excellence for the basic sciences was established in the UP campus and the scientific career system was created to attract scientists to a career path that would professionalize and upgrade the status of scientists. Furthermore, linkage between the academe and the private sector were strengthened with the creation of institutional networks.

Thus, the creation of these councils and research institutes under the NSTA showed a clear shift in science policy from being a technology push strategy to demand pull. In the demand pull strategy, user and market demand serve as the basis for conducting R&D/S&T programs. Thus, scientists and researchers were placed in R&D programs whose results were supposed to have high demand potentials.

After the EDSA revolution in 1986 the NSTA was reorganized into what is now called the Department of Science and Technology (DOST) under Executive Order 128. The DOST, being headed by a Cabinet Secretary, was mandated to continue providing central direction, leadership and coordination of S&T efforts and formulating and implementing policies, plans, programs and projects for S&T development.

For a more effective delivery of certain functions, the DOST was further restructured which resulted in the establishment of the Technology Application and Promotion Institute (TAPI). This particular institute was created to serve as the implementing arm of the DOST in pushing for the commercialization of technologies and marketing the technology services of other operating agencies of the Department. In addition, the Science Education Institute (SEI) was created and mandated to undertake and formulate plans for the development of S&T education and training. Moreover, the Science and Technology Information Institute (STII) was established to serve as the information arm of the Department through the development and maintenance of a S&T data bank and information networks.

The National Institute of Science and Technology was reorganized into the present Industrial Technology Development Institute in order to undertake applied R&D and to transfer R&D results to end-users and to provide technical, advisory and consultancy services in the fields of industrial manufacturing, mineral processing and energy. Entry into the advanced technology areas was formalized with the creation of the Advanced Science and Technology Institute (ASTI). In line with this, additional S&T Councils, namely the PCASTRD and the PCAMRD, were created to further strengthen the Council system.

Furthermore, the leadership of DOST added emphasis on massive technology transfer activities. Specific interventions were initiated through various programs such as the Comprehensive Technology Transfer and Commercialization (CTTC) Program. The CTTC was intended to serve as a mechanism for identifying and pushing concrete results of R&D towards productive application and utilization. The initial phase of the program which covered the period 1989-1992 included a number of technologies whose utilization was envisioned to create substantial impact on the national socio-economic development process and on the lives of many Filipinos, in general. The program covered areas such as financing, technology packages and training centers.

In most R&D institutes technology transfer units were established in order to carry out the added responsibility of transferring completed researches. Provincial S&T Centers were established to help ensure the efficient and effective transfer of technologies in the provinces.

S&T services were also provided in order to supplement R&D and technology transfer. S&T services included the upgrading of testing, standardization and quality control services and various forms of technical assistance and consulting services. Assistance to investors was also provided. This consisted of patenting assistance for inventions with commercial potentials; assistance in the availment of financing for commercially viable inventions; marketing assistance; support to pilot plant operations for selected top priority technologies for commercialization; and lastly, support to the upgrading of inventions, expertise and capabilities.

R&D institutes undertook contract researches to foster the collaboration among the institutes, the private sector and the academe. Furthermore, funding assistance to technology developers and acceptors through the tie-ups with some financing institutions such as Development Bank of the Philippines, Technology Livelihood Resource Center, Land Bank and Private Development Corporation of the Philippines were also initiated.

Incentives were provided under the Omnibus Investment Law for the conduct of certain R&D and S&T activities in the private sector. Some of the major incentives included were: income tax holiday, duty free importation of capital equipment, deduction from taxable income for the necessary and major infrastructure and facilities in less developed areas, access to bonded manufacturing/trading warehouse system and employment of foreign nationals.

To facilitate the transfer of foreign technology, science parks were set up. These parks were also intended to serve as the vehicles for university interaction with private industry; to develop new knowledge-based industries and strengthen existing ones; and to provide a propitious environment for innovation and contract research. Moreover, technology business incubators were initiated in certain areas to assist the transfer and commercialization of technologies by helping ensure the survival and successful growth of new technology firms by providing them with appropriate marketing, financial technical and management assistance.

A Presidential Task Force on S&T was formed, in 1988, specifically to deal with the overall problems confronting R&D and S&T development in the country, and to formulate an S&T Development Plan which supports the national development goal of attaining a newly-industrializing-country status by the year 2000. The task force was composed of DOST, DOA, DTI, DOTC[7], as well as the Presidential Adviser on Public Resources and three academic institutions directly involved in S&T. The task force submitted a report to the President on March 1989, embodying the development of 15 leading edges to steer the country to industrial development. These 15 leading edges were: aquaculture and marine fisheries, forestry and natural resources, process industry, food and feed industry, energy, transportation, construction industry, information technology, electronics, instrumentation and control, emerging technologies, and pharmaceuticals.

To attain the objectives set in the S&T Master Plan (STMP), the following strategies were pursued: (i) modernize the production sectors through massive technology transfer from domestic and foreign sources, (ii) upgrade the R&D capability through intensified activities in high priority sector and S&T infrastructure development such as manpower development, and (iii) develop information networks, institutional building and S&T culture development (Tables IV.12 to IV.13).

During the Ramos administration, the DOST initiated a Science and Technology Agenda for National Development (STAND Philippines 2000) which embodied the country's technology development plan in the medium-term, in particular, for the period 1993-1998. The STAND identified seven export winners, eleven domestic needs, three supporting and coconut industries as priority investment areas. The seven identified export winners are: computer software; fashion accessories; gifts, toys, and houseware; marine products; metals fabrications; furniture; and dried fruits. The domestic needs include: food, housing, health, clothing, transportation, communication, disaster mitigation, defense, environment, manpower development and energy. Because of their linkages with the above sectors, three additional support industries were included in the list of priority sectors, namely: packaging, chemicals and metals. Lastly, because of its strategic importance, special focus was given to the coconut industry, and therefore was included in the list.

There are two key reasons why S&T/R&D policies in the Philippines suffered major setback: (i) underutilization of S&T for development as reflected in the low quality and low productivity of the production sectors; and (ii) weak linkage between technology generation, adaptation and use. Underinvestment in S&T development is in terms of manpower training, technological servicing, R&D facilities and financial resources.

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[7]DOA – Department of Agriculture; DTI – Department of Trade and industry; DOTC – Department of Transport and Communication.

The weak linkage can be attributed to: (i) poor linkage between technology generation, adaptation and use; (ii) slow commercialization of technologies due to weak delivery system; (iii) poor linkages of S&T organizations with industry and other government agencies; and (iv) low appreciation of R&D due to short-term perspective of private and government agencies.

There are possible ways of improving the delivery system and the commercialization of R&D output. Eclar (1991) attempted to investigate some of factors that may be important in improving the delivery system and commercialization. In particular, the study identified user participation as one important factor. Successful commercialization is promoted when a user with a specific need has been identified at the start of the project. The user generally maintains an interest in the progress of the research and takes on the commercialization of the results at the completion of the research project in order to meet his earlier expressed need. This is reinforced when the user's interest in the project is translated into support or cost-sharing. Another important factor, as identified by the study, is pilot testing. Demonstration of the technical viability of the technology in a semi-commercial scale helps convince an industry user to start off commercialization. Commercial success is promoted when the user himself has provided material inputs to the pilot test.

In spite of the expressed importance of S&T and R&D development in the Philippines and the series of well-intentioned strategies, the state of S&T and R&D development remains far behind other Asian countries by any measure. One reason behind this is the low private sector participation in R&D activities. Most developed countries achieved a healthy partnership between public and private sectors in R&D. The bulk of R&D expenditure that originates from the private sector in Japan is 83 percent, Korea 82 percent, Taiwan 65 percent, Singapore 62 percent, Thailand 40 percent. In the Philippines, the share of the private sector remains at 20 percent for R&D expenditure, or even less.

Aside from the problem of underinvestment in R&D, the Philippines also suffers from the shortage of S&T manpower. Because of lack of better and quality employment opportunities in the domestic economy, braindrain of technical personnel as well as S&T professionals results. This is one crippling problem in the S&T manpower development process. In 1992, the Philippines had only 15,610 personnel engaged in R&D activities, representing 152 personnel per million population. The UNESCO puts the critical mass of S&T personnel at 380 per million population to implement the application of technology.

The STMP and STAND 2000 have too many identified areas to be supported with too little financial resources. It is highly doubtful as to how much attention was given to the consideration of the viability of their implementation. There was weak linkage between planning and budgeting, and little consideration of budget availability in plan formulation stage. With insufficient budget allocation, the DOST had to cancel and reduce its financial supports for S&T development programs and projects.

Some Insights. R&D is crucial in a country's development process, yet some economic agents are hesitant in pursing it. This is because there are high risks involved in R&D activities (particularly the uncertainty involved in the outcome of an R&D undertaking), as well as there is high incidence of spillover or externality that is hard to appropriate. Thus, to push R&D activities to the frontier, government interventions are critically needed. But the formulation of what type and form of government intervention to implement is a delicate thing to do, and often times controversial, because of imperfect information. Wrong policy formulation could run the risk of wasting limited government revenue and resources. However, the experiences of Korea and Taiwan show that proper targeting of industries and tailor-fitting of R&D incentive structure could work very well, if accompanied by a sound human resource development. In fact, coordination in these two areas and implementation of a good program for a continuous manpower training and development, propelled and sustained economic growth in these two Asian countries.

Aside from the fact that the Philippines has been underinvesting in R&D, poor coordination and lack of coordinated planning in relation to R&D are two major problems confronting the innovation and technology sector in the country. At the different government departments and agencies, surveys and interviews indicate a seemingly chaotic and confusing system of institutional arrangements because of lack of coordinated focus in terms of strategic sectors and programs. Furthermore, Magpantay (1995) has argued that the DOST has expanded its size too much over the years and has become too complicated a system to be able to perform its functions effectively. The Department is doing a lot of unfocused and not well-programmed set of activities through the different councils and institutions it presently has. Certainly, this leads to institutional inefficiencies. A reorganization of the structure of the Department is called for. Perhaps the recent institutional reforms in

New Zealand can be a model for reforms. Prior to the reforms, the science system in that country was dominated by large government departments with mixed and overlapping roles. However, with the reforms, the system has changed into one that has three separate, independently run, and highly focused parts. These parts form the: (i) technology policy component, (ii) science funding component, and (iii) science operations component. The separation allows each part to focus on its own set of activities, and therefore creates a better system of accountability.

V. Gaps in Research and Development in the Philippines

A. Productivity Indicators.

The Philippine economy performed poorly over the last three decades compared to its Asian neighbors. The Philippines grew an average of 2.5 percent per annum over the period 1980-1996, far below the growth performance of Singapore (8.0 percent), South Korea (8.2 percent), Thailand (8.0 percent), Malaysia (8.2 percent), and Indonesia (7.6 percent). One of the major reasons behind this poor economic performance, as suggested in the literature on Philippine economic development, is the deterioration in productivity.

The declining productivity over the years is borne out in a number of productivity studies done at the macro level. Table V.1 shows some of the estimates of TFP. For example, Willamson (1969) estimated a declining TFP from 55 percent in the period 1947-55 to 15 percent in 1955-65. The results of Sanchez (1983) and Patalinghug (1984) showed relatively constant TFP growth in the 1960s up to the early 1980s. However, the results of Austria and Martin (1992) showed a big drop in TFP growth in the period 1950-87 of -11 percent. According to the authors, this drop in productivity growth can be explained by the inability of the country to allocate its resources efficiently because of policies that intervened in the process of resource allocation.

In a more recent productivity paper, Austria (1997) found that for the period 1960 to 1996, TFP of the entire economy declined by -0.4 percent. However, it is worth noting that in the more recent period, especially in the last 4 to 5 years, productivity improved (see Figure 2). Austria (1997) attributed this improvement to the favorable effects, in particular efficiency effects of the economic reforms implemented.

The overall declining productivity is also reflected at the manufacturing level. The results of Hooley (1985) showed that "over the period 1956-80, TFP decreased by 0.15 percent annually. Since 1975, TFP has been declining at an alarming rate of 2 percent or more per year. For the manufacturing sector as a whole, the data paint a very clear picture: one of slow TFP growth during the late fifties and sixties, unmistakable retardation after 1970, with rates of advance after 1975 assuming significantly larger negative dimensions. When certain additional adjustments for labor quality improvements are made, the average rates are uniformly lower for the entire period as well as for all sub-periods."

In a more recent study on manufacturing TFP, Cororaton et al (1996) came out with productivity estimates that indicate a general decline in productivity. The decline in productivity is mainly caused by the deterioration of technical progress over time. The study suggests this is attributed to the general failure in the approach of acquiring and adapting new or foreign technology.

Cororaton and Abdula (1997) investigated some possible determinants of manufacturing TFP. Among the factors included in the analysis were: exports, imports, tariff protection, domestic wages, government R&D expenditure as a percent of GDP, foreign direct investment and inflation rate. As argued in the paper, each of these variables attempted to capture key features of the economy. For example, inflation rate captures economic stability in the system. In principle, high inflation will deter productivity-enhancing programs and investment. The results of the investigation are shown in Table V.2. One of the major relevant results in the paper is the statistically significant and positive coefficient of the variable that captures R&D efforts. This is indicative of the importance on R&D expenditure as a major factor to focus on any productivity-enhancing program.

Cororaton (1998) found that for the period 1981 to 1996, TFP of the primary sector (which includes agriculture and mining industries) declined by an average of 0.2 percent. Industry TFP improved marginally by an average of 0.9 percent over the same period, while the service sector TFP declined by an average of 2.9 percent.

B. Gaps in R&D

The poor productivity performance in the Philippines can be attributed to the gaps in R&D. This section will discuss indicators of R&D gaps at the national level, as well as at the sectoral level. RD gaps are defined as factors that have prevented the economy or the sector from operating at its full potential in terms of productivity. These factors could be either in the form of (i) low R&D investments and inadequate R&D manpower, (ii) institutional weaknesses as a result of poor system, management and leadership, (iii) policy lapses and failures, or all three combined. However, while it is important to discuss all sectoral issues in detail to be able to understand R&D issues at the micro level, this may not be possible because of limited information. Because of inadequate statistical and accounting system on R&D and S&T activities in the country, there is no sound historical information at the sectoral level. Thus, not all sectors will be covered. Only few sectors will be discussed.

National Estimates

Cororaton (1998) attempted to estimate the R&D gaps in the Philippines through the use of a growth regression model involving TFP of different countries, on the one hand, and the respective R&D spending and manpower, on the other. That is,

TFP = f(R&D investment, R&D manpower)

The basic idea behind this formulation is that R&D investment results in innovations, which in turn results in higher productivity. However, R&D investment cannot turn into real outcome if there are not enough R&D manpower to do the R&D work. Thus, R&D manpower, in particular scientists and engineers, is important.

This relationship was estimated using actual data from different countries with different levels of development. Thus, it can capture countries' experiences and performance through time, and as such, it can provide a good basis for computing the R&D investment gaps for a particular country. In other words, the estimated relationship provides some kind of a world TFP frontier that can serve as the basis for computing R&D gaps.

The equation below is a result of an ordinary least squares (OLS) regression on pooled data for 33 countries. The figures in parentheses () are t-statistics.

$$\mathbf{TFP = -0.0328 + 1.677E\text{-}3{*}R\&DEXP + 7.730E\text{-}6{*}S\&E + (a_i{*}DUM_i)}$$

(-2.169) (1.868) (2.096)

R^2 = 0.276 number of observations = 99

where TFP is total factor whose indicator is derived using growth accounting method, R&DEXP is the ratio of R&D expenditure to GNP (expressed in percentage), S&E is the ratio of the number of scientists and engineers to population, DUM_i is the country dummy variables to capture country differences, and a_i is the corresponding estimated coefficients (note that these coefficients have been generated using the OLS, but it's too long to write them here since there are 32 of those). The coefficient of R&DEXP is significant at 6.6 percent level, while the coefficient of S&E is significant at 4 percent.

Based on this estimated relationship, the following procedure was applied to derive the gaps in R&D expenditure and in R&D manpower in the Philippines:

(i) The residual between the frontier and the TFP for the Philippines was calculated for the decades of the1980s. This calculated residual serves as the basis for the investment gap computation.

(ii) To compute for the R&D expenditure gap the estimated equation was utilized. Thus, the left-hand side of the equation was set to the residual as computed in (i). In the right-hand side of the equation, S&E was set to zero, while R&DEXP was made a variable to be solved. All the estimated coefficients were retained.

Based on the procedure, the resulting R&D expenditure gap is **0.5778**. This means that R&D expenditure-GNP ratio would have to increase by 0.5778 for the Philippine TFP to reach the TFP frontier. The average R&D expenditure–GNP ratio during the 1980s was 0.1667 percent. Thus the total R&D expenditure-GNP ratio needed to reach the frontier is 0.1667 + 0.5778 = **0.7445**. This is a sizeable increase from the current level, but lower than what has been proposed in S&T Bill (House Bill no. 2214) of 1 percent of GNP.

Applying this ratio to the 1997 GNP of P2,527 billion will result in a total R&D expenditure of roughly **P18.8 billion** (i.e. P2,527 billion GNP in 1997 x 0.7445%). This R&D investment gap is substantial considering that the present level of R&D spending is approximately P3 billion. While this is a significant gap, for all intense and purposes, this could not feasibly be financed by the national government because it will result in significant budgetary impact. The government has other equally important and pressing needs, especially in the area of basic infrastructure like market roads, bridges and port, and of social sector like education and health. Furthermore, it may be totally ineffective and inefficient to re-allocate existing limited government resources in favor of R&D activities because of the institutional inefficiencies in the R&D system, as well as in the S&T structure. David (1998), for example, argues that while agricultural research continues to be underfunded, "efficiency of public sector research funding has been significantly lowered by the misallocation of limited budgetary resources, as well as by institutional weaknesses of the agricultural research system". Thus, unless these institutional weaknesses are addressed, additional government funding into R&D will only go to waste and will not result in productivity gains.

In other progressive countries, the bulk of R&D investment comes from the private sector. The challenge therefore is how to encourage the private sector to participate in R&D activities. It is also important to identify the necessary infrastructure, incentive system and investment safeguards needed so as the said sector can do its own R&D.

(iii) Similar procedure as in (ii) was applied to compute for the gap in manpower. The result shows a gap of **197** scientists and engineers per million population. The average ratio for the decades of the 1980s was only 108. For the Philippine TFP to reach the gap it should need R&D manpower of 108 + 197 = **305** per million population.

Sectoral Gaps and Problems

This section will attempt to relate the overall gap discussed above at the national level to the gaps at various sectors. However, since information on R&D at the sectoral level are very limited because of lack of adequate and well-functioning R&D and S&T statistical and accounting system, the analysis at the sectoral level will be done for selected major sectors only. However, despite the limited sectoral coverage, the issues and problems are generally similar across sectors. Thus, the issues and problems in these sectors are indicative of the overall issues and problem surrounding the overall R&D system in the country. The issues largely focus on four major problems: (i) underinvestment in R&D, (ii) lack of adequate and technically capable R&D manpower, (iii) institutional weaknesses and (iv) policy failures. The sectors covered in the discussion are: agriculture, fishery, manufacturing, and to a very limited extent, education, and health. Information on the health sector were taken form the recently completed study of the Center for Economic Policy Research and the Department of Health (CEPR-DOH). The first two sectors fall under agriculture, natural resources, and to some extent, environment. Manufacturing is under industry, while education and health are within the service sector. The discussion is largely based on the sectoral studies done within the R&D project, as well as on other available R&D literature.

Agriculture[8]

Underfunded Research in Agriculture. The agricultural sector performed poorly since the 1980s. David et al (1998) attribute this poor performance to a number of factors, and one of them is the inadequate public support services particularly in agricultural research and development. "The agricultural research system has been severely underfunded with public expenditures in the early 1980s representing only 0.3 percent of agriculture gross value added, in contrast to an average of 1 percent among developing countries and 2-3 percent among developed countries (Table V.3). In fact, only 5 percent of the total public expenditure for agriculture have been allocated for agriculture research; whereas the ratio of budgetary outlay for price stabilization programs alone was in the range of 10 percent over the past decade (Table V.4)."

Apart from the problem of inadequate funding for research, there are other equally important gaps, if not more important ones, in agricultural research. David et al (1998) identified them as: (i) inefficiencies caused by the misallocation of research resources within the sector (e.g., across research program areas and ecological regions) and (ii) weaknesses in the institutional framework of the research system including the organizational structure, lack of accountability, fragmentation of

[8] Largely based on the paper of David et al 1998.

research, incentive problems, instability in leadership and weak linkage between research and extension.

Misallocation of Research Resources. Using the congruence rule, which defines the optimal research resource allocation across commodity program areas as proportional to the respective commodity value added or value of production shares, in other words, given a total budget for agricultural research, the research intensity ratio, i.e., research expenditure as a ratio of the value added should be equal across commodity research program areas, David et al (1998) found that the "allocation of research expenditures across commodities and regions have been highly incongruent to their relative economic importance measures in terms of gross value added contribution of the commodity. In particular, relatively greater research budgets are provided to minor commodities such as cotton, silk or carabao, and too little to major ones such as corn, coconut, and fisheries and others. Furthermore, Mindanao regions are relatively neglected in terms of research budgets of the DA and SUCs compared to regions in Luzon and to a lesser extent to those in the Visayas." They further added that "while congruency does not strictly coincide with optimal research resources allocation, the differences in research intensity ratios observed among commodities and across regions cannot be explained by possible differences in cost research (probability of research success, etc.), future market potential nor equity considerations".

Other indications of misallocation of resources and institutional weaknesses in agricultural research are also discussed in David et al (1998) and Ponce (1998). Some of these are:

(1) Overly High Share for Personal Salaries. The expenditure for personal salaries (PS) on the average tends to be disproportionately high at 58 percent, while maintenance and operating expenses (MOE) is about 36 percent and capital outlays (CO) only 6 percent. In agricultural research systems in more developed countries where salary rates are much higher, the distribution of expenditures is 40 percent for PS, 40 percent for MOE, and 20 percent for CO.

Generally, in almost all research agencies, the shares of PS are high; at least 50 percent. In a number of commodity research agencies and SUCs, the shares can be as high as 70 to 80 percent. PhilRice, however, is an exception. The structure of expenditure is 40 percent for PS, 50 percent for MOE, and 10 percent for CO. This allows for a more efficient utilization of its manpower and physical facilities, as well as promotes more systematic and long-term research planning.

UPLB, which undertakes the bulk of research activities related to agriculture, has also the same expenditure structure with PS share as high as 70 percent. Moreover, research projects under the different institutes, centers and research units of the university are primarily driven by priorities of external donors, which contribute about half of the research fundings. As such, the effectiveness of research is constrained by uncertain and short-tern nature of funding, even though the university may have the most able scientists in the country in different fields in agriculture.

The implication of the expenditure pattern in the different research agencies in agriculture in the Philippines is that, the overly high share of PS may reflect overstaffing, bureaucratic rigidities and poor planning.

(2) Unfocused Projects. An analysis of the work and financial plans and projects completed indicate that research projects are highly fragmented and short-term in nature. Research findings and outputs are not carried to future researches nor used for extension to benefit the clientele. This is because there is no adequate system or clear mechanism whereby research findings are fully transferred to the targeted end-users. Also, there are no systems where researches are continued in a long-term and continuous basis. Thus, the analysis of the profile of the researches indicates that, generally, research projects do not reflect a sense of problem orientation.

(3) No Clear Network Among SUCs. Ponce (1998) argues that SUCs are basically "independent from each other despite their hierarchical designations as national multi-commodity research centers, regional research stations and cooperating stations. The national multi-commodity research center's (UPLB, CLSU, VISCA, and USM) linkage to the regional and cooperating stations are ad hoc in character and project related. There exists no institutionalized linkage resulting from clearly defined complementary functions."

(4) No Clear Network Between DA and Attached Agencies. In addition, Ponce (1998) also argues that the DA research system consists of national experiment stations operated by (i) various bureaus such as BPI, BAI, BFAR, and

BSWM; (ii) attached agencies such as PhiRice, PCC, PCA, SRA and FIDA; (iii) Regional Integrated Centers under the regional offices of the DA; and (iv) Regional Outreach Stations. Similar to the network among the SUCs, "there exists no clear functional delineation between the national stations and the regional experiment stations and between the region and the provisional stations. Each station exists independently of each other in terms of programs even within the DA proper. Thus, national centers do not exactly orchestrate the national research and development programs of their assigned commodities.

(5) No Clear Link with the Private Sector. Furthermore, Ponce (1998) also cites the weak link between the private sector and the larger community of research stations. Most private research centers exist principally to meet the needs of the companies that established them. As such, they do not interact with the rest of the research community dominated essentially by the government sector, except for a few privately-operated research centers that perform public services such as the Twin Rivers Research Center. There is also a mechanism whereby this link could be fostered and developed.

(6) Other Institutional Gaps. Other institutional weaknesses cited by Ponce (1998) are (a) the lack of well-defined and institutionalized mechanism for collaboration among R&D subsystems and (b) the inefficient funding system and lack of accountability. The present funding system is still very much like the old project-approach one where the research outputs are essentially in the forms of research reports. This weakens the system of program approach and leads to distortion of national priorities. Furthermore, the present funding approach gives rise to a much-diffused structure of research implementation where it becomes difficult to pinpoint responsibility.

Manpower Gaps. In terms of R&D manpower profile in agriculture, the authors found that the problem is not in terms of the number, but in the relatively low level of scientific qualification of the agriculture research system. This is particularly true in both the DA and DENR research agencies. The very low ratios of technical manpower resources with advanced degrees at the DA and DENR compare quite *unfavorably* with similar institutions of some of the Asian countries like Malaysia, Indonesia, and even Bangladesh.

On the other hand, the quality of research manpower in SUCs is not uniformly nor always significantly better. Although share of manpower in SUCs may be higher than in agencies, there is a big and worsening problem of in-breeding. Furthermore, local scientists who were trained and educated abroad, are not generally attuned to recent developments or frontier international knowledge. Also, there is a big gap in the quality of faculties and researchers in UPLB and other SUCs.

Fisheries Sector[9]

One of the sectors included in the R&D study is the fisheries sector. This sector is important not only because it has direct impact on national health and nutrition (fish is the source of about 75 percent of the total animal protein requirement of the country, in fact more than poultry and livestock combined) but also because its structure, particularly supply side, is directly affected by what has been happening in the environment. To a certain extent, the fisheries sector can be one output indicator of what has been happening in the environment.

Israel (1998) has pointed out that the weak performance of the fisheries sector has been the result of several interrelated problems which include the top three important ones: (i) resource depletion in coastal waters due to overfishing and destructive fishing, as manifested by the deterioration of important fish stocks and species and the degradation ecosystems; (ii) large-scale environmental damage, as evidenced by the destruction of coral reefs and mangroves in marine areas and pollution of major river lakes; and (iii) proliferation of industrial, agricultural, commercial and domestic activities which discharge pollutants into marine waters, contributing to the deterioration of ecosystems and rendering marine food potentially harmful for consumption.

R&D is important to the development of the fisheries sector, particularly to its long term survival. Primarily, R&D is crucial to generating new information and technologies that can increase output above the current low and dwindling levels.

The responsibility of managing and coordinating fisheries R&D in the Philippines has been the task of the Philippine Council for Aquatic and Marine Research and Development (PCARMRD). The Council, which is under the DOST, is

[9]Based on the paper of Israel (1998).

tasked to plan, monitor, as well evaluate fisheries R&D. The paper of Israel (1998) discusses the R&D structure of the fisheries sector.

Furthermore, PCAMRD interacts with two government agencies whose R&D scope covers the fisheries sector. These agencies are the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA) and the Ecosystem Research and Development Bureau (ERDB) of the Department of Environment and Natural Resources (DENR). These agencies are mandated to coordinate all researches of the regional offices and line agencies within their respective departments. The BAR covers fisheries research because fisheries are administratively classified under the agricultural sector. The ERDB does so since aquatic resources form part of the natural resource base and therefore, falls under DENR.

Institutional Gap and Issues. Israel (1998) found that one of the biggest gaps that results from the present institutional arrangement is the weak coordination and poor collaboration among government agencies. PCAMRD is the agency tasked to manage and coordinate overall fisheries R&D while the BAR and the ERDB coordinate fisheries research of the regional offices and line agencies of their respective departments. Because of the similarity in functions and constituency, potential overlapping existed among the three agencies. To address this problem, they delineated their functions through existing Memoranda of Agreements (MOAs). Implementation of these agreements, however, has been hampered by poor collaboration. In particular, in violation of the MOAs, the agencies do not actually jointly review all research proposals submitted for funding. Furthermore, collaboration is weak or does not exist in several activities and strong only in one aspect.

Aside from poor collaboration, another crucial institutional problem deals with a possible duplication problem between PCAMRD and the Bureau of Fisheries and Aquatic Resources (BFAR) arising from the existing Fisheries Code. The Code reconstituted the BFAR from a staff to a line bureau under the DA and assigned it the function of formulating and implementing a Comprehensive Fishery Research and Development Program. To effect this program, the law created a new agency within BFAR, the National Fisheries Research and Development Institute (NFDRI), which becomes its main research arm. Among the functions of this agency is the establishment of a national infrastructure which will facilitate, monitor and implement various research needs and activities of the fisheries sector and the establishment, strengthening and expansion of a network of fisheries-related communities through effective communication linkages nationwide. These functions of the BFAR and the NFRDI may duplicate those of the PCAMRD. For one, the responsibilities of formulating and implementing an overall plan for fisheries R&D and coordinating its implementing are mandates of the Council. Likewise, the Council has already established a network of research institutions, the NARRDS, to serve as implementing arm for fisheries R&D. At a larger scale, the duplication of functions in the R&D programs of the fisheries and agriculture sectors has been noted by the Agricultural Commission.

Under which agency and department should the task of managing, coordinating and implementing R&D fall is a long running issue that has a life of its own in fisheries circles. At present, this question is far from settled and creates a lot of bureaucratic and institution inefficiencies.

Capability Issues. Capability issues surrounding R&D in fisheries include (i) low investment (including public, private, as well as foreign investments); (ii) funding problems; (iii) manpower shortage and (iv) poor maintenance of existing capital.

(i) Low Public Investment. The most glaring resource-related problem in R&D is historically low government funding that agriculture as a whole receives (Tables V.5 and V.6). In developed countries, average public spending on investment in agriculture R&D is about 2 percent of their agricultural GVA. In contrast, only about 0.019 percent of GVA is allocated locally. Regionally, the Philippines has the lowest R&D allocation for agriculture in Asia.

For fisheries, in particular, allocation averages only about 0.102 percent of fisheries value added which is close to what agriculture is getting. However, the fisheries R&D budget is only about 3.6 percent of the total expenditure for agriculture and natural resources R&D combined. Thus, compared to agriculture and natural resources, fisheries is getting the worse end of the deal in the sharing of government funds.

A look at disaggregate data indicates not only the low government funding for fisheries R&D but also the uneven government allocation among institutions. In 1996, among the NARRDS members, the budget in total magnitude and as ratios to number of researchers and projects differed widely (Tables V.7 and V.8). It can be seen also that the ratios of budget to number of researchers and projects were low for many institutions, including some zonal centers.

To address the problem of low budget for agriculture and fisheries R&D, the AFMA stipulated that allocations be increased to at least one percent of GVA by year 2001. For its part, the Fisheries Code legislated the creation of a special fund for fisheries R&D in the initial amount of P100 million. The AFMA is mute regarding the sharing of funds between agriculture and fisheries. Assuming that allocation will be proportionate to output contribution, the budget for fisheries should jump substantially from its current levels. There is already doubt that the planned increases in allocations will fully materialize soon given the mounting fiscal deficits.

Low Private Investment. Data on private investment in fisheries R&D are scarce. This is understandable given the natural aversion of the private sector to divulge information. This notwithstanding, it is known that private entities have been involved in one way or another in R&D, especially in applied research and technology verification activities where the likelihood of generating new technologies for immediate commercial application is high.

A lot of the private sector involvement in fisheries R&D is in aquaculture. During the rapid development of this industry in the last twenty years, private firms have been collaborating with national institutions and locally based international research agencies in the conduct of applied research covering many commodities including prawn, tilapia, milkfish, crab and other commercially profitable species.

In the commercial fisheries, private sector participation in R&D is limited since research in capture technologies usually requires larger investments and results are difficult to patent. Also, a lot of the research activities, such as stock and resource assessments, have social externalities which go beyond the private interests of private operators and, thus, are better left to government and international research agencies to conduct. The common practice in the commercial fisheries has been to use imported technologies outright or modify to some extent said technologies to suit local requirements and needs.

In the municipal fisheries, private investment in money terms is low because the poor economic position of the municipal fishermen practically prevents them from doing such investment. However, manpower involvement in R&D is substantial among fishermen and their families by way of participation in the conduct of numerous coastal resource management and similar projects undertaken by government and international agencies.

Available data show that overall, the share of private investment in fisheries R&D is low (Table V.9). To promote this type of investment, the AFMA encourages government research agencies to go into co-financing agreements with the private sector provided that the terms and conditions of the agreements are beneficial to the country. For reasons already cited, the possibility of these agreements actually happening will be higher in aquaculture than in the commercial and fisheries subsectors.

Low Foreign Investment. Figures show that the contribution of foreign funding for fisheries R&D was more than half of total funding (Table V.9). In recent years, however, this share has gone down (Tables V.10 and V.11). By 1996, only 7 percent of the total funds of NARRDS institutions came from foreign sources (Table V.12). Furthermore, funding was concentrated only in a few concerns, mostly the environment and OPAs.

Foreign funding is important because it is essentially a signaling mechanism. Low outside investment for domestic R&D could mean that local research institutions and their programs are not internationally competitive and vice versa. Furthermore, in this time of economic crisis, foreign money may be the only viable way of increasing allocations. The AFMA and Fisheries Code did not address the issue of international funding for R&D.

(ii) Untimely Release of Funds. Aside from the low allocations, a commonly cited fund-related problem in fisheries R&D is the untimely release of government funds to institutions, programs and projects. In fact, this constraint is true not only for R&D but also for other activities depending on government support. In fisheries, it is acute because of the importance that time and season play in the conduct of activities. Although there are no data which can be used to validate this, research activities are reported to be cancelled or haphazardly conducted because of the delay in the release of funds. The review of the FSP pointed out other problems related to the management of government funds (PRIMEX and ANZDEC 1996). These include the excessive control by the Department of Budget and Management (DBM) over a large proportion of program funds; the diversion of some funds to other activities not necessarily directly related to the program; the lack of coordination between the DBM and program administrators regarding fund utilization; and the lack of a financial monitoring system for the funds.

(iii) Shortage of Manpower. Earlier figures show that the NARRDS institutions relatively have limited R&D manpower at all levels (Table V.11). They also indicate that personnel capability varies greatly between regions and programs and that senior personnel, especially those with doctorate degrees, are concentrated only in a few institutions (Table V.13). The limited number of doctorate degree holders has been compensated, in some cases, by masteral degree holders. While this is so, it cannot be denied that more doctorate degree holders are required in NARRDS institutions to provide the organizational and research leadership.

A comparison of selected NARRDS and NARRDN institutions suggests that the manpower in fisheries R&D is no more than 10 percent of that in agriculture although the percentage of Ph.D. holders is a bit higher (Table V.14). This proportion is highly uneven and not reflective of the higher ratio of fisheries output to total agricultural production (Table V.15). The graduate to undergraduate ratio of fisheries R&D staff appears to be significantly lower compared to that of agriculture also.

The problem of limited manpower in fisheries R&D, especially in institutions located in the provinces, deserves attention because of the rural nature of many fisheries activities. Researchers working in the countryside are more exposed to the actual problems in fisheries and are in a better position to correctly identify priority research areas for implementation. More of them should be recruited then to enhance the capability of the sector to conduct hands-on and meaningful, instead of "ivory tower", research.

The Fisheries Code did not address the problem of limited R&D manpower in fisheries. The AFMA, on the other hand, stipulated the creation of a science fund to sustain career development. Since, the manpower problem is directly related to funding, the planned increases in the total R&D allotment, should they materialize, will go a long way towards addressing it.

(iv) Low Level and Poor Maintenance of Capital Assets. While the data presented here concentrate only on funding and personnel resources, capital resources, in particular, buildings, facilities and equipment also help determine the success or failure of R&D. In fisheries, the capital resources for R&D have been wanting, more so in provincial institutions which receive smaller shares of the research budget. The problem of inadequate capital assets is worsened further by poor maintenance. There have been reports that proper maintenance is sometimes sacrificed by institutions to meet more immediate expenses, such as salaries and wages. In sites close to the sea, the faster deterioration of capital assets brought about by salt makes the problem of poor maintenance very serious.

Like the manpower problem, the inadequate and poor maintenance of capital assets is function of funding. If the NARRDS institutions get a raise in their allocations, they could purchase enough capital assets and spare money for maintenance. Again, the solution rests a lot on the materialization of the increased allocations promised by the AFMA and Fisheries Code.

Manufacturing

One of the major factors that hindered the study team to conduct a thorough and a detailed study on the manufacturing sector R&D is the lack of historical information that can help track down R&D developments in the sector. As mentioned in Section II, the breakdown of R&D expenditure that is available up until 1992 is entirely different from the sectoral breakdown in the PSIC. As such, historical information is not consistent with what is available in the NSO data system. This is a major hurdle because usually R&D activities, in the form of investments and manpower availability, are analyzed against indicators of sectoral output performance. For example, in the congruence rule discussed in Section III, optimal allocation of R&D budget should be proportional to the respective commodity value added or value of production shares. While the latter is available from the NSO data, the former is not. However, David et al (1998), after a tedious task of gathering and assembling information from almost all sectors in agriculture, were able to apply the analysis in a preliminary way. Based on the analysis, they were able to conclude that R&D allocation in agriculture is *far* from optimal.

However, the same analysis *cannot* be done in the manufacturing sector because of the absence of R&D data. What was done, instead, was to conduct a small survey (Macapanpan, 1998 and Halos, 1998) on selected industries in the manufacturing sector, and company interviews (Nolasco, 1998) within those selected industries, including the BOI. The discussion here is largely based on these papers.

The paper of Macapanpan (1998) is focused on Philippines' private sector innovation activities. It was based on a survey of selected companies from five industry groups: (1) food processing, (2) textile and garments, (3) metals and metal fabrication, (4) chemicals and (5) electronics and electrical machineries. The major conclusions of the study are the following:

(a) Only big firms do engage themselves in innovation. These are industry leaders. Smaller firms may just be 'along for the ride', not even considered "followers".

(b) "Innovations activities are perceived by the firms to improve their competitiveness through improved quality, lower production costs and enhanced marketing performance. *Government standards and regulations and environmental concerns are not important drivers for innovation activities.* As predicted by literature and studies, firms will formulate their technology strategy to support their overall business strategy.

(c) "*The steel industry has not acquired any significant new technology*, in spite of recommendations from various studies. *The same is true for the textile industry, which has fallen behind in modernizing their equipment* to remain competitive, quality- and cost-wise."

(d) "Of the total respondent firms (more than 60), only seven firms employ Ph.Ds and only about 20 have masteral degree performing any innovation activity. *A majority employ only college graduates or lower in their innovation activities, implying a very low level of innovation activity*."

(e) "*Government research institutions rank very low as a source of innovation ideas. From interviews, the perception of the firms is that these research institutions lag even in monitoring technology developments in their respective fields*. Internal R&D is not relied upon, except by the firms in the electronics and electrical industry. Ideas for innovation activities are usually sourced from the outside in the form of consultancy services, information on competitor activity generated by monitoring, purchase of technology, tangible and intangible, and the recruitment of manpower with the required skills."

(f) "Financial constraints such as risk and rate of return, lack of financing and taxation are the major hindrances to innovation. Technical constraints such as lack of information on new technologies, deficiency in external technical services, innovation costs, and uncertainty rank next as barriers to innovations. Others mentioned include difficulty in obtaining patents, low technological standards, lack of skilled personnel, and lack of opportunities for cooperation with other companies."

(g) "Philippine firms are deficient in experience and organization to fully exploit technology as a source of competitive advantage. This situation is not helped by the lack of government assistance and support. Government has been remiss in aligning the educational system toward a globally and technologically competitive economy. The requisite technical and technological skills and knowledge are not provided by the Philippine schools. Government research institutions have not diffused their findings to the private sector."

Based on a survey, Macapanpan (1998) therefore was able to identify major gaps and stumbling blocks that prevent the private sector from fully exploiting the benefits of being technological-attuned and -updated productive units. Moreover, based on interviews, Nolasco (1998) identified further gaps and major loopholes in the system:

(i) The overall system is loose and chaotic in the sense that different government agencies do have different set of prioritized sectors. Furthermore, some of the goals are unaligned. For example, NEDA, DTI and BOI have different set of strategic sectors. DFA and NEDA have conflicting interests with the BOI industry planners, especially in terms of granting incentives. In particular, DOE is looking into the possibility of developing wind energy while DOST is eyeing the solar energy.

(ii) Government, with such limited amount of budget allotted to R&D, limits the amount of expenditure on R&D.

(iii) Support facilities like testing centers, either government-run or government subsidized, standardization institution and support industries like casing and others are lacking or non-existent. Access to recent and state-of-the-art technologies is lacking due to poor databases.

(iv) System only reaches out to a handful of firms, usually the larger ones. Small and medium scale firms have minimum access to the system.

(v) People and staff in the incentive promotion desk are not too familiar with the system of incentives. For example, some of them are not even aware of (a) the contents of the R&D incentives scheme LOPA and (b) the fact that R&D incentives existed for more than six years. Most of them would recall that R&D has been integrated into the IPP LOPA only in the past two years, when in fact, it has been there since early 1991.

(vi) Government and private sector linkages are very weak. Thus, commercialization of developed technologies has not well been promoted.

As a result of these gaps and problems, only 11 companies or a total of 13 projects were granted incentives during the period 1991-1997.

Meanwhile, the results of Halos (1998) on the survey and interview with private firms in the chemical industries, which produce chemical inputs into agriculture (such as fertilizer and pesticides), indicated that there has been a considerable reduction in R&D investments. The exceptions are in the sugar and coconut industries where research funds have been mandated by government. In fact, the intensity of research activities by the private sector, except sugarcane and coconut, appears to have declined from the level in the 1980s. Information on R&D are scarce and hard to come by, but there are clear indications of this slowdown. For example, a number of multinational pesticide companies used to maintain research groups distinct from marketing group but only two have remained to do so at present. The regional research station of a multinational agri-chemical firm has reduced not only the number (from 5 to 3) but also the rank of its research staff (from 2 senior and 2 junior level).

Another observation of Halos (1998) deals with the government policy. For sure, the government has adopted a policy of promoting local innovations and R&D activities. This is manifested in a major legislation, RA 7459, which was signed into law in April 1992. The law provides multi-incentives package to encourage the development of inventions and facilitate their commercial application. For example, "the law provides for presidential awards, tax/duty exemptions, loan assistance and invention assistance development in prototyping, piloting, training, study tours, attendance to conferences/seminars and laboratory tests and analyses. Various councils of the DOST provide counterpart R&D funds to private companies. Although respondents agreed that tax exemption for R&D equipment is conducive to their R&D initiatives, interviewees found the *procedures too cumbersome*. Similarly, they found the *availment procedures and equity requirements for technology-commercialization loans cumbersome and too steep for small entrepreneurs.*" In fact, producers of organic fertilizers bewail the data required for FPA registration.

In general, Patalinghug (1998) argues that small and medium enterprises face several problems to acquire technology or to engage in R&D. "Among these problems are: (1) lack of funds, (2) insufficient information, (3) lack of skills in evaluating alternative technologies, (4) lack of technical know-how to shift to more advanced technologies, (5) inadequate mechanism for transfer of technologies and (6) inertia of entrepreneurs because of no perceived or actual need for technology."

Education

The Philippines ranks low in terms of the number of R&D personnel. In 1992, the ratio of the number of scientists and engineers per million population was 152. From the supply side, this low level of S&T and R&D personnel is a result of the country's educational system that produces very low science and engineering-related graduates. While the number of students at the tertiary level is high in the Philippines, the number of tertiary students taking up science and engineering-related courses is low (Table V.16). There is in fact a dilemma in the present education system because of the educational "mismatch": while there is a great demand for technical and engineering-related graduates by local industries, private tertiary schools continue to produce non-technical graduates.

This is, indeed, a big policy area problem. One of the factors that would explain this is that private schools prefer not to go into these technical related courses because of their high laboratory requirement that is capital intensive. Non-technical courses are less laboratory intensive and therefore less capital intensive.

The pool of R&D manpower is dominated by people with basic college degrees and generally have very limited advanced technical training. This in itself presents a big stumbling block because new technologies available are already in advanced state and require special technical skills. Thus, the lack of adequate R&D

manpower places the country in a very disadvantaged position because it does not have enough technical capability to adopt, through R&D, developed technologies in the market. In other words, with inadequate technological capability, the Philippine may find it difficult to catch-up in terms of access to and mastery of the key emerging or leading-edge technologies. This, in turn, negatively affects future growth and international competitiveness.

Furthermore, in a recent survey conducted by the Philippine Institute for Development Studies (Cororaton et al, 1998) on R&D activities of government agencies and state universities and colleges (SUCs), it was observed that more than 40 percent of R&D personnel with Ph.D. degrees are in social sciences while only less than 10 percent are in engineering and technology (Figures V.1 and V.2). About 35 percent are in agriculture-related sectors.

This inadequacy of supply of R&D manpower can be traced back to the problem in basic education which is at the moment in a poor state. The bad shape in the basic education is rooted to the teacher training policy of the country and the status of teaching profession (Magpantay, 1985). "To be able to teach in high schools, teachers must have BSE with a major and minor field. This degree program is short on the content and heavy on the methodology of teaching. In the end, teachers are knowledgeable in the standard way of teaching but do not know what to teach. And worse, the students, who enter the education colleges, are generally not very creative and imaginative due to low status afforded the profession. In any family, the intelligent among the children are encouraged to take up medicine, law and if mathematically inclined, engineering while the least academically capable are asked to take up BSE or BSEE programs. It is no wonder then that the science and math educations in the primary and secondary levels are in bad shape. Students are taught by the least academically inclined people who went through a program that emphasizes more on the form than on the content".

The poor S&T educational system results in low supply of skilled manpower (Sachs, 1988). "In particular, there is a severe shortage of science teachers at the school level. The quality of science education at the college level is also poor. A substantial fraction of highschool science teachers have no training in science and mathematics (but rather have degrees in education). Highschool math and physics curricula are badly in need of reform. A World Bank funded engineering and science education project has provided scholarship for masters and doctoral training in science and engineering but the scope of the project is limited. In general, there is a lack of capacity to do research, which will become particularly problematic in the future when forms will have greater demand for adopting and innovating existing technologies. Increasing the supply of science and technology education is probably the most crucial investment in science and technology that needs to be made *now.*"

Health

The present study did not have the opportunity to include an analysis on the health sector R&D. However, the Center for Economic Policy Research (CEPR), under the funding from the Department of Health, recently conducted an analysis of the funds flow of health research and development in the Philippines. Among the major objectives of the analysis were to: (a) trace the flow of health R&D resources; (b) assess the system for setting health R&D priorities; and (c) determine if health R&D funds match with the priorities of the research agenda.

Some of the major insights derived from the CEPR-DOH findings, which are relevant to the present R&D gaps analysis in this section, include:

(i) "Of the P394 billion government budget for 1996, health resources accounted for P75 billion or 19 percent while R&D resources had a meager share of P3 billion or less than one percent.

(ii) Resources for health R&D amounted to P421 million; this was equivalent to 17 percent of R&D resources and one percent of health resources. The latter is below two percent of the national health expenditures, the proportion recommended by the Commission for Health Research and Development for health R&D"

Other Important Gaps

Eclar (1991) discussed the long history of S&T and R&D in the Philippines. In fact, its beginnings can be traced back to the American colonial period. There were significant changes since then, including changes in the structure, system, leadership and administration. Recently, programs and plans have been launched like the Science and Technology Master Plan (STMP) in 1990 and the Science and

Technology Agenda for National Development (STAND) in 1993. However, there are no successes that can be cited. There are, however, clear indications of failure (Patalinghug, 1998). For example, the S&T sector faces the following major problems: (a) underutilization of S&T for development as reflected in the low quality and productivity of the production sector and heavy dependence on imports; (b) underinvestment in S&T developments in terms of manpower training, technological services, R&D facilities and financial resources; (c) weak linkages between technology generation, adaptation and utilization; and (d) slow commercialization of technologies because of very weak delivery system, which in turn is the result of weak linkages especially between government research institutes and the end-users.

Patalinghug (1998) further cited that "there has been a general failure to use technology to gain competitive advantage. Resource-based exports (timber, copper) are basically in raw material or unprocessed form. Traditional agricultural exports (coconut, sugar, and banana) are also exported without infusing technology-based processing in the value-added chain. The shift from primary exports (coconut, sugar) to manufactured exports (garments, electronics) has simply reflected the changing factor composition of exports (that is, from resource-intensive to labor-intensive). The shift from labor-intensive to skill-intensive or technology-intensive manufactured exports has not yet occurred."

Institutional Weaknesses. There are a number of clear institutional gaps. Some of these include:

(i) Failure in Execution and Implementation. Patalinghug (1998) made a comparison between the S&T system in the Philippines and in South Korea. One of his observations was that, "basically, in form and intent, the Philippine S&T development plan is comparable to that of Korea. Thus, the basic weakness of the Philippine experience is in its execution and implementation. Although there are some weaknesses in the plan-formulation process in the Philippines because the planning exercise is detached from the budgeting exercise, the more decisive factor is the weakness and organization arrangement to ensure timely and correct implementation."

There are big defects within the existing intra-government coordination system. In particular, the system of performance monitoring and evaluation is lacking or defective. "In fact, the government's Investment Coordination Committee (ICC, chaired by NEDA) has been lengthily reviewing projects intended to address the adverse effect of the financial crisis. But basing from the ICC's inefficiency in evaluating development projects, it is more likely that these projects will be approved at a time when the economic conditions they are supposed to address are no longer there. The ideal institutional arrangement is definitely to establish a coordination mechanism between S&T plan, the budget plan and the Medium Term Philippine Development Plan. Unfortunately, prospects of establishing this linkage in the Philippine bureaucracy, in the short run, are not promising".

(ii) Other Causes of Institutional Failure. Some argues that Korean leadership has the political will and the consensus among its stakeholder to give top priority to S&T development in the allocation of resources. Magpantay (1995), on the other hand, claimed that the DOST is a highly inefficient structure largely because it "*is doing too many S&T activities, charged with too many functions, operating in a bureaucracy with too many constraints and given too little support*". This is manifested in the DOST's STMP 15 leading edges and STAND 22 R&D priority areas. These areas are all-inclusive and practically cover all industries and all technologies with too little financial resources. This is a clear example of poor planning and poor budgeting. Patalinghug (1998) in fact concluded that "the most reasonable conclusion that can be made is that both STMP and STAND cannot be implemented. Their defects are the following: (1) budgeting and planning were not harmonized in the drafting of the S&T plan; (2) capabilities of implementing agencies were ignored; (3) solid support from various stakeholders was lacking; and (4) therefore resources for S&T development were insufficient. By any standards, the amount actually used for R&D in the DOST budget is absolutely too little".

(iii) Failure of Industrial Policy. There are renewed attempts to formulate industrial policy (Patalinghug, 1998). This is a reiteration of the vital role of industrial progress to sustain future economic growth in the country. "However, ad hoc or de facto industrial policies (as formulated by EDC, IDC, and SMEDC) have not stressed the need for active promotion of technology to build a strong foundation for industrialization". The STAND has identified what is called "export winners" or "industry/product winners". Patalinghug argues that identifying these winners without technology is like a vehicle without an engine.

There are at least twelve priority sectors that have been implicitly identified in the recent pole-vaulting strategy. However, the technologies in support of these "must-do" programs have yet to be identified.

VI. Conclusions &Recommendations

I. R&D Investments

It has been established here and in the various papers written under the R&D project that there is a significant underinvestment in R&D in the Philippines. This is true at the national, as well as at the various sectoral levels. For example, Cororaton (1998) estimated a gap in R&D expenditure of 0.5778 percent of GNP at the national level. David et al (1998) also observed significant underinvestment in agriculture. Israel (1998) also found the same thing in the fisheries sector. Underinvestment in R&D is also very apparent in the private, manufacturing sector as observed by Macapanpan (1998) and Halos (1998). The recently completed study on the flow of R&D funds in the health sector by CEPR-DOH (1998) also found significant underinvestment in R&D.

Moreover, the survey of literature conveyed the fact that rates of return to R&D investments are high. Thus, the finding of underinvestment in R&D and high rates of return would imply high opportunity cost. While it is extremely difficult to compute this opportunity cost because of lack of information, it is manifested in other indicators like productivity. Productivity performance in the Philippines has been very poor. In fact, this has been the major factor behind its unsustainable growth path. In principle, R&D activities lead to innovation, to technological progress and finally to economic growth and prosperity. There is a huge body of literature that would support this.

The biggest issue at hand is: Who would fill in the gap? Rough calculations indicate that there is a gap of about P14 billion at current prices. For sure, the government sector cannot fill in this gap because of financial constraints. Furthermore, the government has other equally important concerns such as basic infrastructure and other social sector needs. Naturally, it has to be the private sector (either local or foreign). However, the private sector responds to proper incentives. Further discussion on this is given later in the section.

Part of the gap can be attributed to the inefficiency of allocation of resources. In fact, in agriculture, David et al (1998) argued that misallocation of public sector research funding is an equally important consideration as underinvestment. They cited specific examples. Using the congruence rule, they found that "relatively greater research budgets are provided to minor commodities such as cotton, silk, or carabao and too little on major ones such as corn, coconut, fisheries and others. Furthermore, Mindanao regions are relatively neglected in terms of research budgets of the DA and SUCs compared to regions in Luzon and to a lesser extent to those in the Visayas. While congruency does not strictly coincide with optimal research resource allocation, the differences in research intensity ratios observed among commodities and across regions cannot be explained by possible differences in cost of research (probability of research success, etc.), future market potential nor equity considerations"

Other manifestation of misallocation of resources is in the allocation of budgetary resources by type of expenditure. David et al (1998) also observed that "too little resources are available to perform research activities and to properly maintain the physical facilities, after the salaries of personnel have been paid. Indeed, the average share of personal services to direct budgetary outlays is close to 60 percent and as high as 70 to 80 percent in many cases. Consequently, either the research manpower is underutilized or the research agenda is driven by donors' priorities".

Due to lack of information because of extremely poor databases on R&D activities, misallocation of research resources in other sectors like the manufacturing cannot be conducted. However, given the nature and the extent of problems in the R&D system in the Philippines, the issues on agriculture seem generic to all sectors of the economy.

Aside from underinvestment and misallocation of research resources, there is another big problem of untimely release of funds to institutions, programs and projects. In fact, this is true not only to R&D, but also to other activities that are depending upon government funding and support. Israel (1998) mentioned this as one of the major concerns in the fisheries sector. "In fisheries, it is acute because of the importance that time and season play in the conduct of activities. Although there are no data which can be used to validate this, research activities are reported to be cancelled or haphazardly conducted because of the delay in the release of funds".

Patalinghug (1998) has recommended that DBM must be involved with DOST in the S&T and R&D planning formulation stage so that S&T and R&D resources are made available to implement such plan without delays. This issue will also be touched upon later in the discussion on institutional arrangement.

II. R&D Manpower

The issues surrounding R&D manpower are equally, if not more problematic. This is because the problems in this area can be traced back to the educational system which is not only difficult to reform, but also, its effects would take a long time to be realized if ever reforms are successfully implemented. Lag time would usually take about 15 to 20 years - the required time to properly educate and equip the children with the necessary skills and talents before they enter the workforce.

Cororaton (1998) estimated that the gap in the R&D manpower is about 197 scientists and engineers per million population. In agriculture, David et al (1998) observed that the R&D manpower is not so much in terms of the number, but in relatively low level of scientific qualification of agriculture research. They, in fact, gave a warning that there is an *urgent* need to strengthen manpower capability in DA and DENR research agencies. Israel (1998) also observed a severe shortage of qualified personnel in the fisheries sector. The same is true in the private manufacturing sector (Macapanpan, 1998 and Halos, 1998). In fact, in the recent PIDS survey (Cororaton et al, 1988), it was observed that majority of R&D personnel have only basic college degrees. A small percentage has doctoral degrees mostly in social sciences. A very tiny percentage of Ph.D. holders are in engineering and technology.

While the Philippine educational system produces one of the biggest numbers of college graduates, compared to other countries, it generates one of the smallest number of graduates with science and engineering skills (Cororaton, 1998). There are a host of factors behind this. At the tertiary level there is a dilemma in the present educational system because of the educational “mismatch”: while there is a great demand for technical and engineering-related graduates by local industries, private tertiary schools continue to produce non-technical graduates. One of the factors that would explain this is that private schools, which dominate the tertiary level, prefer not to go into these technical related courses because of their high laboratory requirement which is capital intensive. Non-technical courses are less laboratory intensive and therefore less capital intensive.

At the secondary or high school level, a substantial fraction of high school science teachers have no formal training in science and mathematics (Magpantay, 1995 and Sachs et al 1998). Rather, they have degrees in education. There is, therefore, an urgent need to reform high school math and physics curricula. This problem also holds true at the primary level.

In almost all sectors, the lack of adequate manpower surfaces out. Thus, for the country to sustain a long term growth there is an *urgent* need to reform the science and technology education system. In fact, investment in science and technology education is the most crucial investment that needs to be made now (Sachs et al 1998). Otherwise, it would be too late since returns to this investment have usually very long gestation period or time lag.

Patalinghug (1998) offered specific recommendations: (1) Strengthen S&T education at the elementary and secondary school level. The quantity and quality of elementary and secondary teachers of science and mathematics must be addressed in the Medium-Term Philippine Development Plan: 1999-2004; (2) A strong science and engineering program is also needed to support an expansion of science and engineering enrollment at the tertiary level. Expand the facilities of science and engineering institutions. Encourage the hiring of qualified faculty from abroad; (3) Intensify the effective recruitment of Filipino scientists and engineers working abroad by designing an incentive program that matches the cost of ESEP[10]; and (4) Expand the Philippine Science High School system.

III. Incentive System

People, especially the private sector, respond to incentives. Incentives which are particularly important to R&D activities include: (1) stable economy; (2) institutional protection; (3) access to capital and financing, especially by the SMEs; (4) good R&D infrastructure; and (5) fiscal incentives.

Normally, there are high risks involved in R&D activities. In particular, there are uncertainties in the outcome of an R&D undertaking. Positive and favorable results of an R&D undertaking will not emerge 100 percent or with certainty. In fact, there are great possibilities of failure. Furthermore, there is high incidence of spillover or externality that is hard to appropriate. In this regard, government intervention is critically needed.

There is ample literature and empirical evidence that support the fact that a stable macroeconomy helps encourage productivity-enhancing activities like R&D, especially by the private sector. Therefore, a conducive macroeconomy is one of the major incentives that can be offered to private investors. The role of the government is particularly important in being able to manage the economy so that inflation rate, interest rates, risk premiums and etc. are kept at the minimum.

There are also clear indications from the literature that institutional protection is critically needed. Institutional protection comes in the form of patents and intellectual property rights. These issues have not been addressed in detail in the R&D study (however, this requires a very detailed study because there are crucial policy issues here), but certainly there are problem areas that need to be ironed out in these areas. To be sure, there are indications that the number of patents granted declined through time.

Macapanpan (1998), Halos (1998) and Nolasco (1998) observed through company interviews and surveys that one of the major constraints preventing some of the firms, especially the SMEs, from conducting and pursuing R&D activities and plans is the lack of access to cheap capital and financing. The cost of capital in the Philippines is traditionally high because of distortions in the financial system.

R&D and S&T infrastructure is also one crucial incentive that could attract the private sector to pursue technology-related activities. Proper infrastructure could come in the form of (1) a strengthened educational system which can produce a workforce with adequate R&D capabilities, good and updated data bases and information system; (2) wide and easy-to-access network on technology developments; (3) a mechanism whereby Filipino scientists and engineers working abroad can come home back to work; and (4) a mechanism whereby research results and output of research institutions and universities can be delivered to the end-users, among others.

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[10] South Korea did this in the early 1960s with great success.

Macapanpan (1998), Halos (1998) and Nolasco (1998) also noted that fiscal incentives are important in attracting the private sector to go into R&D activities. Cororaton (1998) listed down some of the major fiscal incentives in the Philippines and noted that these are generally similar to the ones offered by South Korea. However, fiscal incentives have to be handled properly, as these would have significant budgetary implications. Furthermore, although fiscal incentives are important, results would indicate that there are major inefficiencies in the granting of incentive in the BOI. For example, Nolasco (1998) noted that from 1991 to 1997, only 11 companies or a total of 13 projects were granted with incentives. Patalinghug (1998) therefore suggests that there is a need to "design an incentive package, with strict qualifying requirements on what constitutes R&D activities, to encourage private sector R&D. An external peer review committee is recommended to act as the screening mechanism"

Other important incentive issues, which need attention, are discussed in Israel (1998). In particular, it was noted that in most cases, researchers conducting research using the funds of their own agencies are granted with minimal financial incentives. Remunerations from projects funded by other government sources have been incompetitively low. As a result, many researchers tend to do odd jobs not related to research, or consulting work for the private and international organizations. The results of the PIDS survey on R&D manpower, particularly on R&D personnel with Ph.D. degrees, would also indicate this trend (Cororaton et al 1998).

The Magna Carta for the Government Science and Technology Personnel (R.A. 8439) was recently passed to address the problem of low incentives, but it remains to be seen whether this will solve the problem. In particular, the law allows for the provision of honoraria, share of royalties, hazard allowance and other benefits to science and technology workers.

Furthermore, Patalinghug (1998) has additional recommendations which can improve the S&T incentives. These include: (1) allocation of an annual funding for the implementation of the Scientific Career System (SCS). However, entry into SCS should be limited by giving top priority on the target groups, natural scientists and engineers; and (2) implementation of a competitive bidding, strictly based on merit, in the awarding of research projects by pooling a major portion of the country's R & D resources to be administered by an NSF-type agency.

IV. Institutional Arrangement and S&T Coordination Mechanism

From all indications, there is no doubt that the entire R&D system, as well as the general S&T system, is in a state of disarray. Given the extent of the problems, they are almost insurmountable. There are systems, as well as administrative failures, that result in wrong implementation of the plans, projects and programs. There are also policy failures due to the lack of focus on technology in the overall development strategy. To address these problems, Patalinghug (1998) recommended the following reforms: (a) DBM must be involved with DOST in the S&T plan formulation stage so that S&T resources are available to implement the plan; (b) STCC must draft a Medium-Term Science and Technology Development Plan a year before the drafting by NEDA of the next Medium Term Philippine Development Plan. An inter-agency joint committee must integrate the Medium Term Science and Technology Development Plan into the Medium Term Philippine Development Plan by decomposing them into annual budget plan, annual S & T plan, and annual economic plan, and then harmonizing its goals, projects, programs, strategies, resource requirements, and timetables; (c) DOST must establish a Project and Program Monitoring Unit staffed by at most three persons whose main job is to coordinate the selection, through competitive bidding, of external evaluators and reviewers for the different projects and programs implemented under the S & T plan; and (d) An STCC chaired by the President must meet at least once every three months to address current problems that pose obstacles to the implementation of the S&T plan. An MOT unit attached to DOST (just like PIDS is attached to NEDA) will act as the technical secretariat of STCC under the direct supervision of the DOST Secretary.

V. R & D Delivery System

Eclar (1991) has noted that there is very slow commercialization of technologies in the Philippines. This is largely due to the very weak delivery system and poor linkages of S&T organizations with industry and other government agencies. To improve the linkages Patalinghug (1998) has a number of recommendations:

(1) Reorganize the government-supported R & D institutes into a new corporate structure that gives them flexibility as well as responsibility to gradually develop its fiscal autonomy. The Crown Research Institutes (CRIs) of New Zealand is

one model that needs to be examined. CRIs create opportunities for better R & D collaboration and transfer of technology between the public and the private sector. Its structure also provides full commercial powers.

(2) Establish funding schemes through DOST and CHED to support consortium or network of schools to maximize use of resources.

(3) Focus funding support for developing core competence in targeted regional universities. For instance, University of San Carlos can specialize in chemistry and chemical engineering; MSU-IIT in mechanical engineering, and Xavier University in biochemistry and agricultural engineering.

(4) Promotion of S & T culture by giving Presidential Awards to outstanding science and engineering projects selected through a nationwide competitive search. Encouragement of science TV and radio programs, fairs, plant tours, and apprenticeship.

(5) Install a scanning and monitoring scheme of world technological trends for dissemination to local industries, research institutes and universities.

Eclar (1991) conducted a comprehensive analysis of factors affecting commercialization of technologies. Her study identified user participation. Successful commercialization is promoted when a user with a specific need has been identified at the start of the project. The user generally maintains an interest in the progress of the research and takes on the commercialization of the results at the completion of the research project in order to meet his earlier expressed need. This is reinforced when the user's interest in the project is translated into support or cost-sharing.

Another important factor is pilot testing. Demonstration of the technical viability of the technology in a semi-commercial scale helps convince an industry user to start-off the commercialization process. Commercial success is promoted when the user himself has provided material inputs to the pilot test.

VI. Statistical Information and Accounting System

Good and accurate analysis of R&D opportunities is one of the major factors that would help encourage private, as well as public, investment into R&D and S&T-

related activities. This is because, normally, there are high risks involved in R&D investments (particularly the uncertainty in the outcome of an R&D undertaking), as well as there is high incidence of spillover or externality that is hard to appropriate. These uncertainties and other market failures can be minimized if the statistical information and accounting system is well established. A good information system leads to good analysis on the structure and nature of R&D activities. If there are significant market failures, with good analysis, then appropriate and correct policy measures can easily be formulated to correct these market kinks. However, the present statistical information and accounting system is extremely poor. It generates very inaccurate information of the variables of particular interest in policy. This assessment is based on the recent R&D survey conducted by PIDS (Cororaton, et al, 1998). Thus, there is an urgent need to overhaul the statistical information and accounting system on R&D and S&T activities. The first major step involves making the survey questionnaire consistent with the accounting system of the institutions so that information can flow immediately from the information system of the respective institutions into R&D database. The next major step involves reconciling the variables in the questionnaire consistent with the NSO-PSIC sectoral breakdown. The third recommendation deals with institutionalizing the data system in NSO, because of their expertise in gathering information and their extensive nationwide network, so that regular information is generated and regular monitoring and analysis are conducted.

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TABLES AND FIGURES

Table II.1. Preliminary Estimates of National R&D Expenditure, by Major Sectors
(In Thousand Pesos)

Sectors	1993	1994	1995	1996
Total Expenditure:				
Without adjustment	1,537,910	1,686,332	2,024,379	2,425,763
(Growth, %)		9.7%	20.0%	19.8%
With adjustment	2,119,444	2,321,210	2,828,628	3,403,577
(Growth, %)		9.5%	21.9%	20.3%
I. Higher Education:	380,029	419,801	457,063	531,981
- State Universities and Colleges (SUCs)	292,330	322,924	351,587	409,216
Survey Results	123,520	137,602	141,754	169,358
GAA SUCs *	168,810	185,322	209,833	239,858
GAA UP System	129,053	129,026	154,280	191,135
GAA other SUCs	39,757	56,296	55,553	48,723
- Private Schools	87,699	96,877	105,476	122,765
II. Government Agencies :				
Without Adjustment **	647,690	707,102	895,742	1,089,052
With Adjustment ** ' ***	1,036,304	1,131,363	1,433,187	1,742,483
- Survey Results	436,825	528,954	634,943	688,021
DOST	79,279	92,120	99,150	109,465
- Actual R&D expenditure, DOST	290,144	270,268	359,949	510,496
- Adjustment ***	388,614	424,261	537,445	653,431
III. Non-Government Organizations:				
Based on unadjusted totals	112,926	123,824	148,646	178,119
Based on adjusted totals	155,626	170,442	207,700	249,918
IV. Private Sector:				
Based on unadjusted totals	397,265	435,605	522,928	626,611
Based on adjusted totals	547,484	599,603	730,677	879,195

* General Appropriations Act for R&D of SUCs with no response in survey

** Computed as Survey ***plus*** Actual R&D expenditure of DOST ***plus*** Adjustment ***less*** DOST Survey. The last item corrects for double counting

*** 60 percent of survey ***plus*** actual R&D expenditure of DOST ***less*** DOST survey. To correct of those agencies which have not responded.

Table II.2. Preliminary Estimates of National R&D Manpower, By Major Sectors (head count)

	Full Time				Part Time			
Sectors	**1993**	**1994**	**1995**	**1996**	**1993**	**1994**	**1995**	**1996**
Total:	7,817	8,883	9,135	9,896	3,862	4,516	4,669	5,346
growth, %		13.64	2.83	8.34		16.94	3.38	14.51
I. Higher Education: [6]	2,961	3,397	3,500	3,865	2,423	2,780	2,863	3,162
State Universities and Colleges	2,369	2,718	2,800	3,092	1,938	2,224	2,291	2,530
Survey Results [1]	425	431	465	466	775	816	1,599	1,589
Others SUCs [2]	1,944	2,287	2,335	2,626	1,163	1,408	692	941
Private Universities and Colleges [3]	592	679	700	773	485	556	573	632
II. Government Agencies: [5]	3,294	3,694	3,789	3,993	1,004	1,237	1,291	1,616
Survey Results [1]	2,973	3,719	3,858	4,070	825	1,034	1,107	1,336
DOST [1]	863	935	895	909	24	62	59	69
Actual DOST [4]	1,184	910	826	832	203	265	243	349
III. Non-Government Organizations [6]	548	629	648	715	153	175	181	199
IV. Private Sector [6]	1,014	1,163	1,198	1,323	283	324	334	369

1. Direct from survey results
2. Other SUCs which did not respond, or responded but no information on R&D personnel
3. 20 percent of total higher education R&D personnel
4. From annual report of DOST
5. Survey results ***plus*** actual DOST ***less*** DOST survey
6. Estimated using average manpower distribution for the period 1989-1992

Table II.3. Distribution of Population, Respondents and R&D Establishments of the STA Survey, 1993-1996

	Gov't Agencies	SUCs/VOCTECH	*TOTAL*
SURVEY POPULATION			
Figures	181	234	415
% to Total	43.6	56.4	100.0
RESPONDENTS			
Part 1 Figures	102	113	215
% to Total	56.4	48.3	51.8
Part 2 Figures	97	114	211
% to Total	53.6	48.7	50.8
WITH R&D			
Part 1 Figures	68	74	142
% to Total	37.6	31.6	34.2
Part 2 Figures	65	93	158
% to Total	35.9	39.7	38.1
WITHOUT R&D			
Part 1 Figures	34	39	73
% to Total	18.8	16.7	17.6
Part 2 Figures	32	21	53
% to Total	17.7	9.0	12.8

Table II.4. Comparison Between DOST Survey and DOST Actual Expenditure

	DOST		1993	1994	1995	1996		1993	1994	1995	1996
DOST01	ASTI	SURVEY	14,033,000	19,817,000	17,645,000	27,472,000	ACTUAL	14,231,513	19,913,767	9,209,378	59,966,578
DOST02	FNRI	SURVEY					ACTUAL	12,133,803	13,082,058	26,330,217	31,433,032
DOST03	FPRDI	SURVEY					ACTUAL	20,079,870	15,233,839	30,825,247	44,782,788
DOST04	ITDI	SURVEY					ACTUAL	55,479,000	48,061,566	66,665,283	88,637,551
DOST05	MIRDC	SURVEY	5,811,000	4,002,000	9,067,000	6,401,000	ACTUAL	16,246,000	16,596,000	24,388,000	27,153,000
DOST06	NAST	SURVEY	0	0	0	0	ACTUAL	0	0	0	12,101,473
DOST07	NRCP	SURVEY					ACTUAL	4,160,738	3,763,835	3,307,000	2,912,243
DOST08	PAGASA	SURVEY	19,267,000	23,266,000	26,416,000	23,223,000	ACTUAL	20,177,669	23,266,160	26,416,034	23,222,759
DOST09	PCASTRD	SURVEY	0	0	0	0	ACTUAL	18,633,364	17,806,193	17,875,194	19,320,935
DOST10	PCCARD	SURVEY	15,429,000	19,349,000	14,590,000	6,573,000	ACTUAL	22,390,056	27,223,788	26,907,030	40,066,693
DOST11	PCAMRD	SURVEY					ACTUAL	7,849,455	3,800,000	1,343,822	5,498,500
DOST12	PCHRD	SURVEY	0	0	0	0	ACTUAL	2,017,795	3,830,356	4,179,583	9,877,022
DOST13	PCIERD	SURVEY					ACTUAL	3,000,000	1,795,539	7,758,418	14,067,000

DOST14	PHIVOLCS	SURVEY	3,712,000	5,545,000	5,444,000	7,558,000	ACTUAL	3,574,105	4,521,057	4,943,366	7,016,925
DOST15	PNRI	SURVEY	12,818,000	13,721,000	15,945,000	23,095,000	ACTUAL	10,667,152	11,613,947	14,329,941	19,869,377
DOST16	PSHS	SURVEY	0	0	0	0	ACTUAL	0	0	0	0
DOST17	PTRI	SURVEY	8,209,000	6,420,000	10,043,000	15,143,000	ACTUAL	5,042,478	5,674,796	11,649,898	17,733,386
DOST18	STII	SURVEY	0	0	0	0	ACTUAL	0	0	0	0
DOST19	SEI	SURVEY	0	0	0	0	ACTUAL		1,001,000		
DOST20	TAPI	SURVEY	0	0	0	0	ACTUAL	0	0	0	0
	OSEC*	SURVEY					ACTUAL	74,461,128	53,084,172	83,820,486	86,836,367
		TOTAL	**79,279,000**	**92,120,000**	**99,150,000**	**109,465,000**	**TOTAL**	**290,144,126**	**270,268,073**	**359,948,897**	**510,495,629**

* Not included in the survey

Table III.1. Determinants of TFP Growth in Manufacturing

Variables	Coefficients	t-tests
Constant	5.316	(27.267)
Exports(-1)	0.148	(8.581)
Imports(-1)	-0.519	(-18.522)
D(Tariff)	-1.74	(-33.438)
Wage	-0.126	(-9.353)
DRD(-1)	**0.101**	**(9.353)**
FDI(-2)	0.005	(-14.081)
INF	-0.153	(-14.081)
INF(-1)	-0.468	(-23.088)
Adjusted R2	0.997	
DW	0.65	
F-Stat	448.63	

Where:
Exports(-1): real growth of exports, lagged one period
Imports(-1): real growth of imports, lagged one period
D(tariff): period differential of average nominal tariff rates
Wage: growth of research and development expenditure as % of GDP lagged one period
FDI(-2): foreign direct investment
INF: inflation
INF(-1): Inflation, lagged one period

Source: Cororaton and Abdula (1997)

Table IV.1. Estimated Rates of Return to R&D

	Number of Studies	Estimate not Significant	Significant Estimates Range of Estimates (%)				
			1-24	25-49	50-75	75+	Mean
Public Sector Agriculture Research							
Africa	10	1	2	3	3	1	41
Latin America	36	2	14	22	13	13	46
Asia	35	2	7	20	23	25	56
All Developing Countries	85	5	23	45	40	44	80
All Developed Countries	71	5	21	54	26	29	48
Private Sector Industrial Research							
Developing Countries	5	0	0	3	3	2	58
Developed Countries	35	0	10	20	10	5	44
Public Sector Agriculture Extension							
Developing Countries	17	1	4	2	4	6	50
Developed Countries	6	0	1	0	3	2	63

Source: Evenson and Westphal (1995)

Table IV.2. Rates of Return to Investment in Agricultural Research for Selected Countries and Commodities

Country	Commodity	Annual Rate of Return (%)
Malaysia	Rubber	24
Indonesia	Rice	133
Japan	Rice	25 - 27
USA	Corn	35 - 40
Mexico	Corn	35
Australia	Sugarcane	40 - 50
India	Sugarcane	63
South Africa	Sugarcane	40 - 50
Philippines	Rice	11 - 20
	Corn	29 - 48
	Sugarcane	51 - 71
	Mango	85 - 107
	Poultry	154 - 163
	Coconut	12 - 48

Source: Librero (1997)

Table IV.3. Outline of the S&T Development Strategy: Korea

Period	Industrialization	S&T Development
1960s	- Develop import-substitution industries - Expand export-oriented light industries - Support producer-goods industries	- build up infrastructure - strengthen S&T education and technical training - promote foreign technology imports
1970s	- expand heavy and chemical industries - shift emphasis from capital import to technology import - strengthen export-oriented industrial competitiveness	- expand S&T education and technical training - improve institutional mechanism for adapting imported technology - promote research and development applicable to industrial needs
1980s	- transform industrial structure to one with comparative advantage - expand technology-intensive industries - encourage manpower development and productivity	- develop and acquire top-level scientists and engineers - launch the national R&D Project - promote industrial technology development and industrial labs
1990s	- promote structural adjustment and technological innovation in industries - promote efficient use of human and other resources - improve information networks	- reinforce the National R&D Project to develop core and fundamental technologies - strengthen demand-oriented technology development system - globalize R&D systems and improve information networks

Source: 1993 Science and technology Policy in Korea, MOST, Republic of Korea.
Quoted from Ki-Soo, 1996.

Table IV.4. Progress of Industrial Technology

	1960s	1970s	Since mid-1980s
Target Industries	Basic and light industries	Heavy and chemical industries	Strategic conventional and selected high-tech industries
Technical Task Emphasis	Importation of technologies	Assimilation of the imported technology	Technology generation through indigenous R&D
Form of Technology Acquisition	Dependence on technology importation	Imitation of imported technology	Creation through domestic R&D activities
Critical Human resources	Foreign experts and skilled workers	Local technical personnel	Local scientists and engineers
Production technology	Non-existence	Insufficient	Relatively sufficient
Supply source of components and parts	Foreign-made	Mostly foreign	Mostly local
Technology Transfer	Grant-in-aid	Mostly dependent on importation	Mostly import but export some technologies
- technology transfer form	Package form Turn-key project	Foreign investment and Joint Venture	Direct investment and cross-licensing
- target technology	Degraded technologies	Mature technologies	R&D stage and application stage

Source: Science and Technology Long-term Development Plan, MOST, 1986
Quoted from Ki-Soo, 1996.

Table IV.5. Among the main functions of the MOST include:

- The provision of technology forecasts for the setting up of the basic policy for S&T development;
- The implementation of national R&D projects including core technology, future-oriented technology, big science and technology, and nuclear technology;
- The provision of support to basic and applied R&D activities conducted by government-sponsored institutes, university R&D centers and private sector R&D institutes;
- The formulation of policies for R&D investment, human resources, information and international cooperation in S&T;
- The promotion of the commercialization of developed technology and joint research among industries, academe and research institutes;
- The promotion of public awareness and understanding of S&T, construction and management of science towns as a mecca for advanced industries;

Table IV.6. Incentive Measures for the Private Sector in Korea

- Tax deduction of a maximum of 4 percent of the total sales on the reserve fund for R&D technical information, R%D manpower and facilities;
- Tax deduction of up to 15 percent of total expenditures on HRD and in-house technical training centers and colleges.
- Tax deduction of up to 10 percent of their investment for R&D facilities.
- Application of depreciation rate 90 percent a year on R&D and test facilities.
- Support of up to 50 percent of R%D expenditure when private industrial R&D institutes are involved in national R&D projects.
- Provision of financial support of up to 90 percent of total cost when small firms commercialize new technologies.
- Extension of support of up to 80 percent of total R&D investment by GOCCs when relevant private R&D institutes and R&D unions develop indigenous R&D products.
- Provision of long-term, low interest loans for R&D and commercialization to the private industries by KDB, the Citizens' National Bank, and the IBK.
- Comprehensive financial support by the Korea Technology Banking corporation (KTB) to private companies for technology development activities.
- Information service on technology data collection, application and distribution.
- Implementation of standardization and quality control such as KS and KT.
- Protection of intellectual property rights for new invention and innovations.
- Introduction of a new bidding system based on price and quality.
- Administrative assistance for joint research among industry, university, and GSRI.

Table IV.7. R&D Expenditure and R&D Institutes by Sector in Korea

	Public Sector			Private Sector		
	Institute	Researcher	Expenditure	Institute	Researcher	Expenditure
1989	222	10204	718 (20)	1855	56016	2803 (80)
1990	221	10434	814 (19)	1884	60069	3333 (81)
1991	240	10529	1020 (20)	2111	65723	4178 (80)
1992	265	14434	1098 (18)	2821	74330	5138 (82)
1993	261	16068	1295 (17)	3057	82696	6320 (83)

* *non-profit institutes are included in the public sector.*
Source: Ki-Soo, 1996.

Table IV.8. Programs for S&T Manpower Development in Korea

- Enlarging of university enrollment in the areas of science and engineering.
- Restructuring of the undergraduate system into a graduate-education orientation.
- Operation of 15 science and high schools nation-wide and expansion of current undergraduate and graduate programs of the KAIST.
- Establishment of the Kwangju Advanced Institute of Science and Technology.
- Expansion of a Post-Doc program and diversification of the training countries.
- Assistance to joint graduate program among university, industry and GSRI.
- Assistance of establishing In-company technical Colleges and tax incentives.
- A program of repatriation of Korean scientists and engineers from abroad.

Table IV.9. PCGNP, SE/MP, and GERD/GNP

Among 91 Countries of the World

No.	Country	Per Capital GNP (US$)	Scientists/ Engineers per million population	Gross Expenditure on R&D / GNP (%)	Year
1	Switzerland	37,930	2,409	1.8	1989
2	Japan	34,630	5,677	3	1992
3	Denmark	27,970	2,341	1.8	1991
4	Norway	26,390	3,159	1.9	1991
5	United States	25,880	3,873	2.9	1989
6	Germany (Federal)	25,580	2,882	2.8	1989
7	Iceland	24,630	3,067	1.1	1991
8	Austria	24,630	1,146	1.4	1989
9	Sweden	23,530	3,081	2.9	1991
10	France	23,420	2,267	2.4	1991
11	Belgium	22,870	1,856	1.7	1990
12	Singapore	22,500	1,284	0.9	1984
13	Netherlands	22,010	2,656	1.9	1991
14	Canada	19,510	2,322	1.6	1991
15	Kuwait	19,420	924	0.9	1984
16	Italy	19,300	1,366	1.3	1990
17	Finland	18,850	2,282	2.1	1991
18	United Kingdom	18,350	2,334	2.1	1991
19	Australia	18,000	2,477	1.4	1990
20	Israel	14,530	4,836	2.1	1984
21	Brunei Darusalam	14,240	91	0.1	1984
22	Ireland	13,530	1,801	0.9	1988
23	Spain	13,440	956	0.9	1990
24	New Zealand	13,350	1,555	0.9	1990
25	Qatar	12,820	593	0	1986
26	Cyprus	10,260	205	0.2	1992
27	Portugal	9,320	599	0.6	1990
28	Korea, Republic	8,260	1,990	2.1	1992
29	Argentina	8,110	350	0.3	1988
30	Greece	7,700	53	0.3	1986
31	Slovenia	7,040	2,998	1.5	1992
32	Seychelles	6,680	281	1.3	1983
33	Uruguay	4,660	686	-	
34	Mexico	4,180	226	0.2	1984
35	Gabon	3,880	189	0	1987
36	Hungary	3,840	1,200	1.1	1992
37	Trinidad & Tobago	3,740	240	0.8	1984
38	Chile	3,520	364	0.7	1988
39	Malaysia	3,480	326	0.1	1992
40	Czeckoslovakia	3,200	3,247	1.8	
	a. Former		4,190	3.3	1989
	b. Czech Republic		3,248	1.8	1992
41	Mauritius	3,150	361	0.4	1992
42	South Africa	3,040	319	1	1991
43	Brazil	2,970	391	0.4	1985
44	Venezuela	2,760	208	0.5	1992
45	Russian Federation	2,650	5,930	1.8	1991

No.	Country	Per Capital GNP (US$)	Scientists/ Engineers per million population	Gross Expenditure on R&D / GNP (%)	Year
46	Croatia	2,560	1,977	-	1992
47	Turkey	2,500	209	0.8	1991
48	Thailand	2,410	173	0.2	1991
49	Poland	2,410	1,083	0.9	1992
50	Costa Rica	2,400	539	0.3	1992
51	Latvia	2,320	3,387	0.3	1992
52	Fiji	2,250	…	0.3	1986
53	Belarus	2,160	3,300	0.9	1992
54	Peru	2,110	273	0.2	1981
55	Ukraine	1,910	6,761	-	1989
56	Tunisia	1,790	388	0.3	1992
57	Colombia	1,670	39	0.1	1982
58	Paraguay	1,580	248	0.03	
59	Jamaica	1,540	8	0	1986
60	Jordan	1,440	106	0.3	1989
61	El Salvador	1,360	19	0	1992
62	Lithuania	1,350	1,278	-	1992
63	Ecuador	1,280	169	0.1	1990
64	Romania	1,270	1,220	0.7	1992
65	Bulgaria	1,250	4,240	0.7	1992
66	Guatemala	1,200	99	0.2	1988
67	Uzbekistan	960	1,760	-	1992
68	***Philippines ****	***950***	***152***	***0.2***	***1992***
69	Indonesia	880	181	0.2	1988
70	Macedonia(FYR)	820	1,258	-	1991
71	Bolivia	770	250	1.7	1991
72	Egypt	720	458	1	1991
73	Sri Lanka	640	173	0.2	1991
74	Congo	620	461	0	1984
75	Senegal	600	342	-	1981
76	Honduras	600	138	-	
77	China	530	1,128	0.5	1991
78	Guyana	530	115	0.2	1982
79	Guinea	520	264	-	1984
80	Pakistan	430	54	0.9	1990
81	Central African Rep	370	55	0.2	1990
82	Benin	370	177	0.7	1989
83	Nicaragua	340	214	-	1987
84	India	320	151	0.8	1990
85	Nigeria	280	15	0.1	1987
86	Guinea-Bissau	240	263	-	
87	**Vietnam**	200	334	0.4	1985
88	Nepal	200	22	-	1980
89	Madagascar	200	22	0.5	1988
90	Burundi	160	32	0.3	1989
91	Rwanda	80	12	0.5	1985

*1992 Figures computed by DOST.

Basic source of data: UNESCO, Statistical Yearbook (1995); UNESCO, World Science Report (1996); World Bank, World Development Report (1996).

Table IV.10. Tertiary Education Across Selected Pacific Rim Countries

Country	(1)	(2)	(3)	(4)	(5)	(6)
China (1991)	2,124,121	0.17	80,459	3.79	59,748	74.26
Japan (1989)	2,683,035	2.13	85,263	3.18	54,167	63.53
South Korea (1991)	1,723,886	3.83	92,599	5.37	28,479	30.76
Australia (1991)	534,538	2.92	92,903	17.38	26,876	28.93
Singapore (1983)	35,192	1.13	1,869	5.31	532	28.46
Malaysia (1990)	121,412	0.58	4,981	4.1	1,251	25.12
Thailand (1989)	765,395	1.24	21,044	2.75	4,928	23.42
New Zealand (1991)	136,332	3.78	13,792	10.12	2,863	20.76
Philippines (1991)	1,656,815	2.39	63,794	3.85	5,520	8.65

***Column Definition*:**
1) : Number of students at tertiary level
2) : Number tertiary students as percent of population
(3) : Number of post-baccalaureate students
(4) : Post-baccalaureate as % of Tertiary Students
(5) : Number of post-baccalaureate science & engineering students
(6) : Post-baccalaureate science & engineering as percent of post-baccalaureate students

Source: Basic source of data UNESCO World Science Report (1996).

Table IV.11. DOST Councils

PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PCIERD	Philippine Council for Industry and Energy Research and Development
PCHRD	Philippine Council for Health Research and Development
PCASTRD	Philippine Council for Advanced Science and Technology Research and Development
NRCP	National Research Council of the Philippines

Table IV.12. Summary of Science and Technology Policies by Strategy

1. Modernization of Production Sectors

   1.1 Generation and active Diffusion of Employment oriented and High Value added Technologies.
   1.2 Emphasis on Developmental R&D towards Commercialization.
   1.3 Proper Selection and Acquisition of Essential and Appropriate Technologies.
   1.4 Adaptation, Absorption and Mastery of Imported Technologies.
   1.5 Dissemination of Appropriate.
   1.6 Technologies Increasing Accessibility to S&T information and Services.
   1.7 Reducing Environmental Degradation and Mitigating Adverse Impacts of Natural Hazards.

2. Upgrading of R&D Activities

   2.1 Establishing R&D Priorities.
   2.2 Development of Local Materials and Indigenous Technologies.
   2.3 Stimulation of Private Sector Participation.
   2.4 Reducing Environmental Degradation and Mitigating Adverse Impacts of Natural Hazards.

3. Development of S&T Infrastructure

   3.1 Development of High Quality S&T Manpower in Growth Areas.
   3.2 Expansion of S&T Education and Training.
   3.3 Development of S&T Institutions.
   3.4 Development of an S&T Culture

Source: Eclar (1991)

Table IV.13. Summary of S&T Policy Programs in the Philippines

		Policy and Program	Brief Description
1		Modernization of the Production Sectors	
	A	Comprehensive Technology Transfer and Commercialization Program (CTTC)	The CTTC serves as a mechanism to link technology generators and users. It aims to hasten the process of industrialization through commercialization of technologies whose utilization is envisioned.
	B	Support programs to the CTTC	
	B-1	Production of technology packages	Provision of info and economic feasibility studies
	B-2	Investors For a	Venues for technology generators
	B-3	National and Regional Technology Fairs	Organized to showcase new technologies for transfer
	B-4	Technology Financing Programs	Funding assistance to technology
	B-5	Information Services	Info packages on mature technologies
	B-6	DOST Training Centers	Conducts technology training
	B-7	Regional and provincial S&T Centers	Ensure the transfer of technologies
	B-8	DOST Academy Technology Business Entrepreneurship Development Program	Link between DOST and the Academe for technology commercialization
	C	Technology Business Incubators	Assists new technology firms through technical, financial and marketing assistance
	D	Science and Technology Parks	Facilitates the transfer of university-industry inter-action in advanced technology
	E	Global Search for Technology	Search and acquisition of commerciable technologies abroad
	F	Program of Assistance to investors	Assistance to patenting, financing and marketing
2		Upgrading of R&D Activities	
	A	R&D Priority Plan (Export winners, basic domestic needs, and coconut industry)	Indication of preferred areas of R&D
	B	Grant-in Aids program	Support of R&D activities
	C	Contract Research Program	Sponsored research with other agencies
	D	R&D Incentive Programs	Incentives for the conduct of R&D activities
3		Development of R&D Infrastructure	
	A	Manpower Development Program in Science and Engineering	Graduate and undergrad scholarship program in priority areas
	B	Grade school and secondary school level	Dev't of the grade school network serving as feeder schools for HS and technical schools
	C	Vocational and Technical Education	Dev't of vocational and technical schools in the industrializing areas
	D	Scientific Career System (SCS)	Career path for scientists that will develop their technical expertise
	E	Utilization of Filipino Exports	Employment of Filipino expatriates
	F	Recognition of S&T Efforts	Conferment of the rank and title of National Scientists
	G	Balik Scientists Program	Taking advantage of trained Filipino scientists and engineers thru information exchange
	H	Development of S&T Culture	Promotion of science consciousness and innovativeness
	I	Organizing and Strengthening of S&T Network and Institutions	Strengthening of S&T sectoral network and establishment of new S&T institutions and mechanisms

Figure IV.1. R&D Expenditure/GNP vs Per Capita GNP

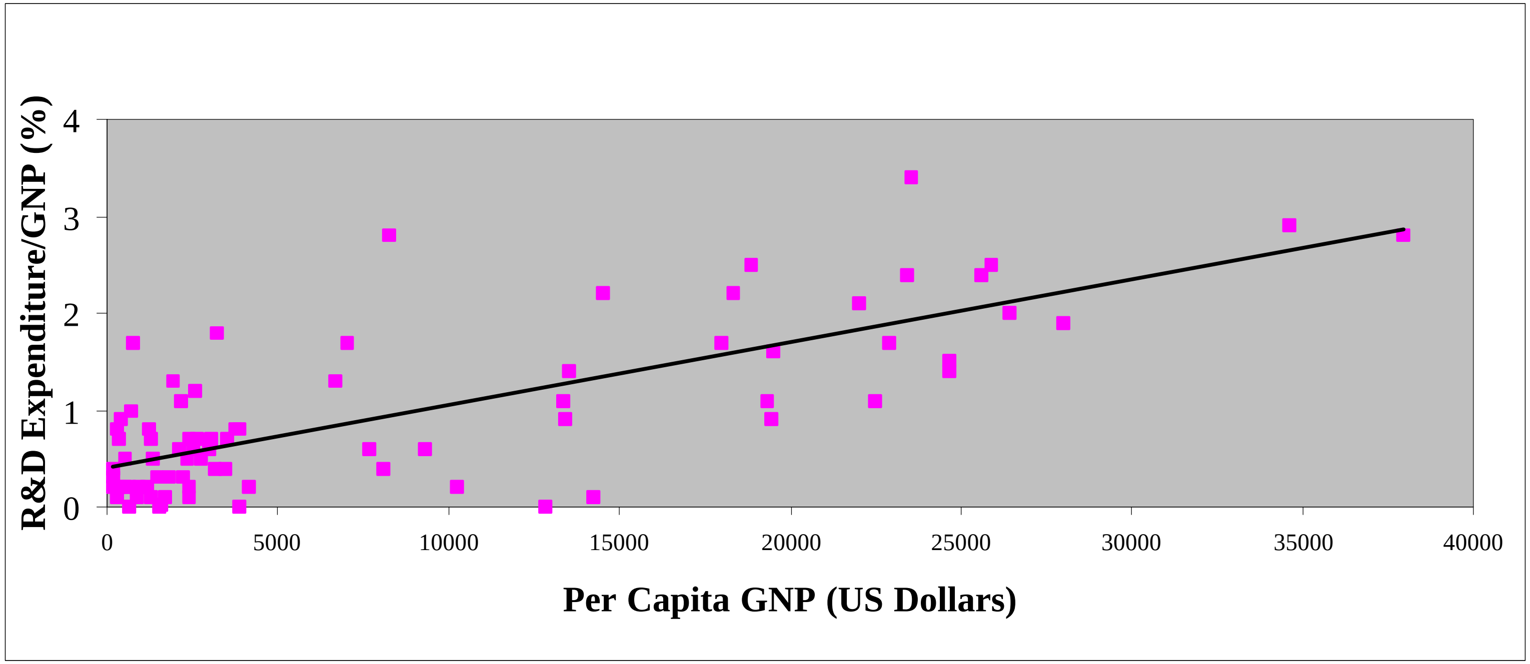

Figure IV.2. Scientists and Engineers per Million Population

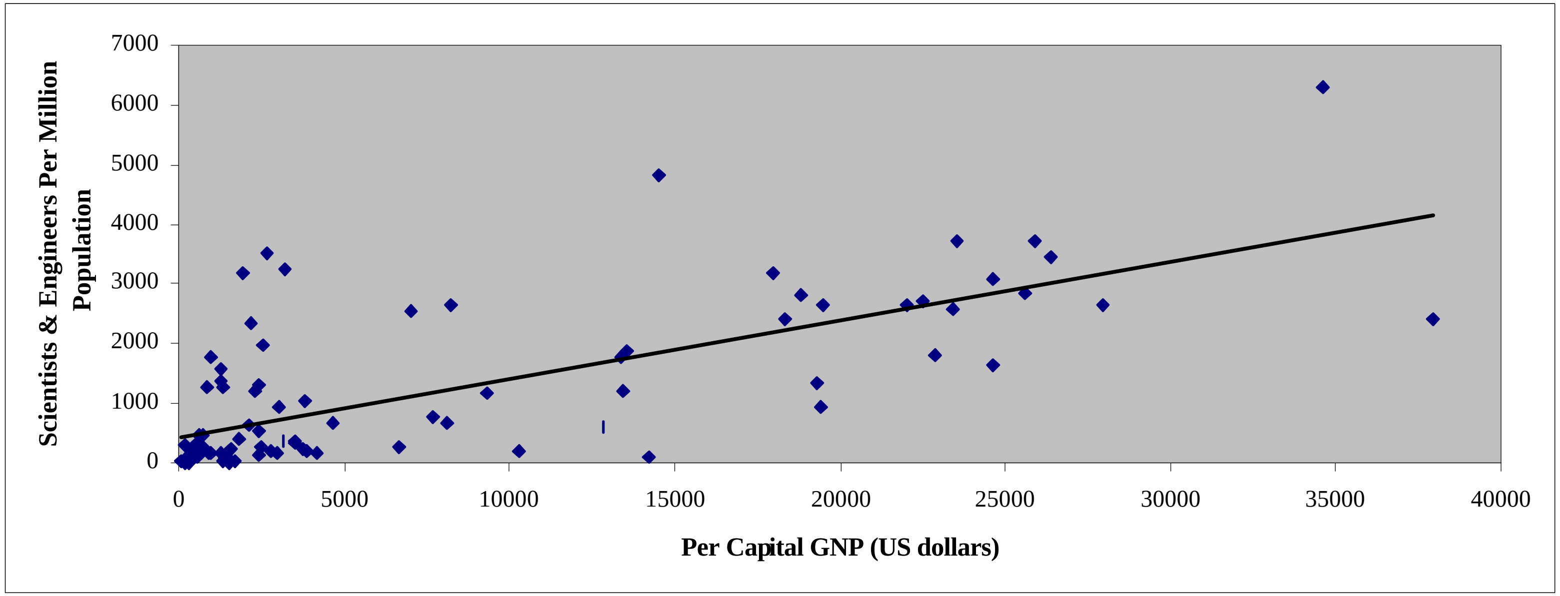

Figure IV.3. TFP vs Ratio of R&D Exp/GNP

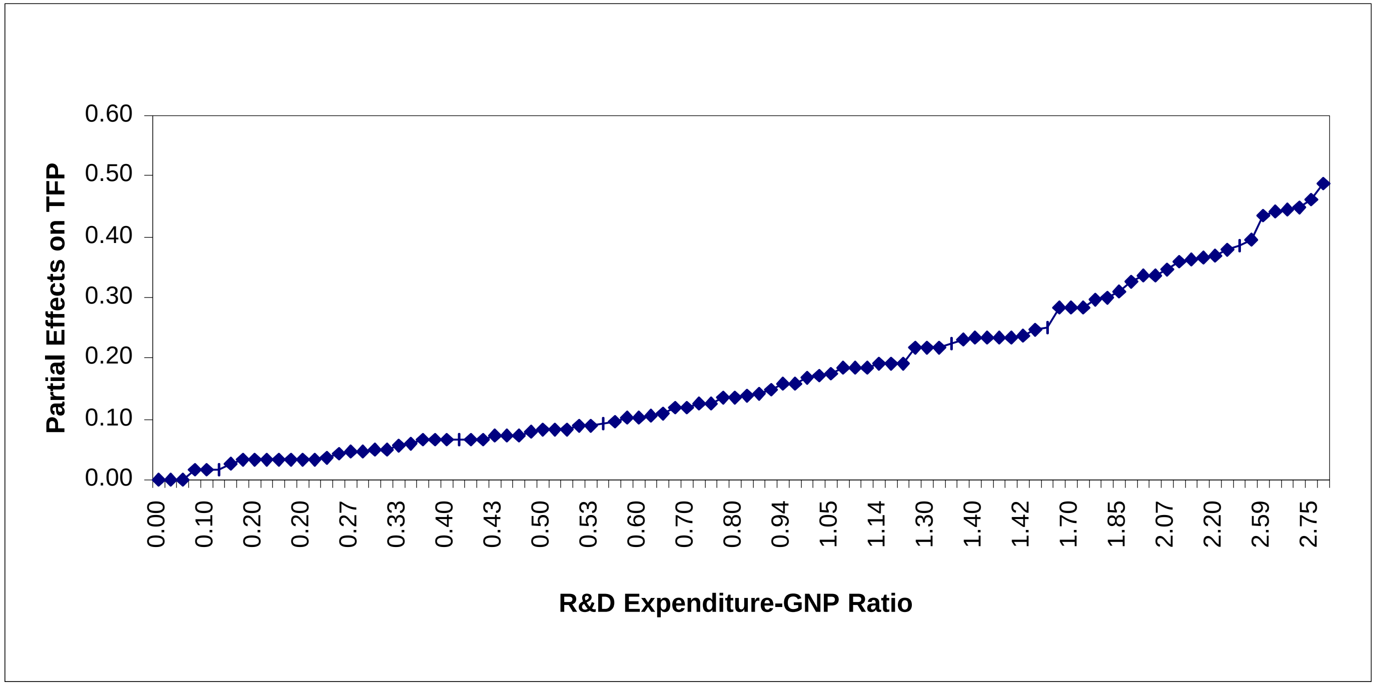

Figure IV.4. TFP vs Ratio of S&E/Pop

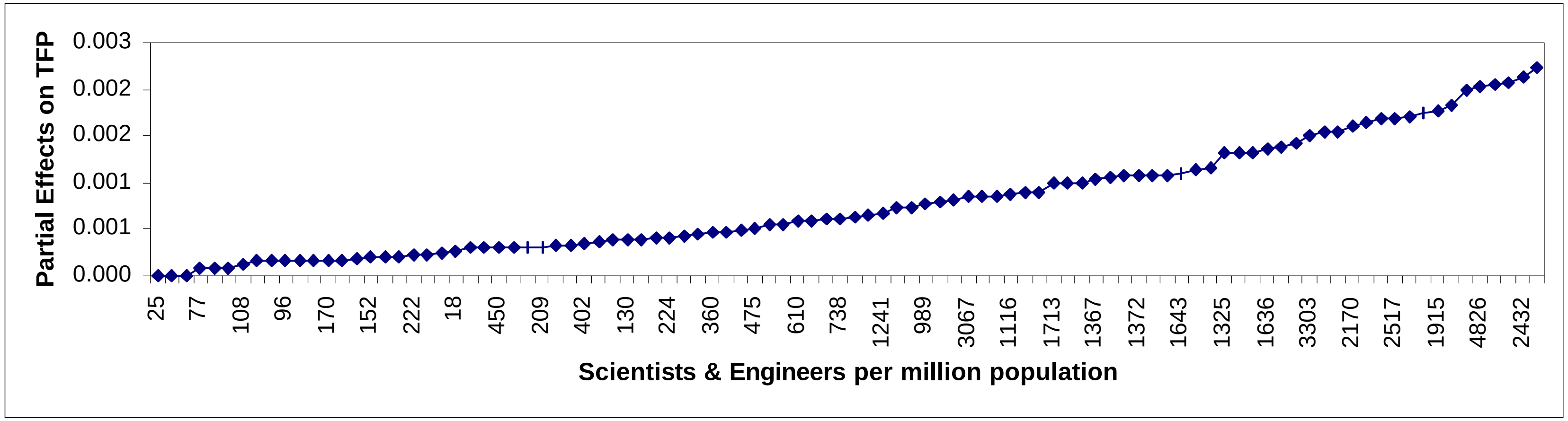

Figure IV.5. Percentage of R&D Expenditure by Sector of Performance

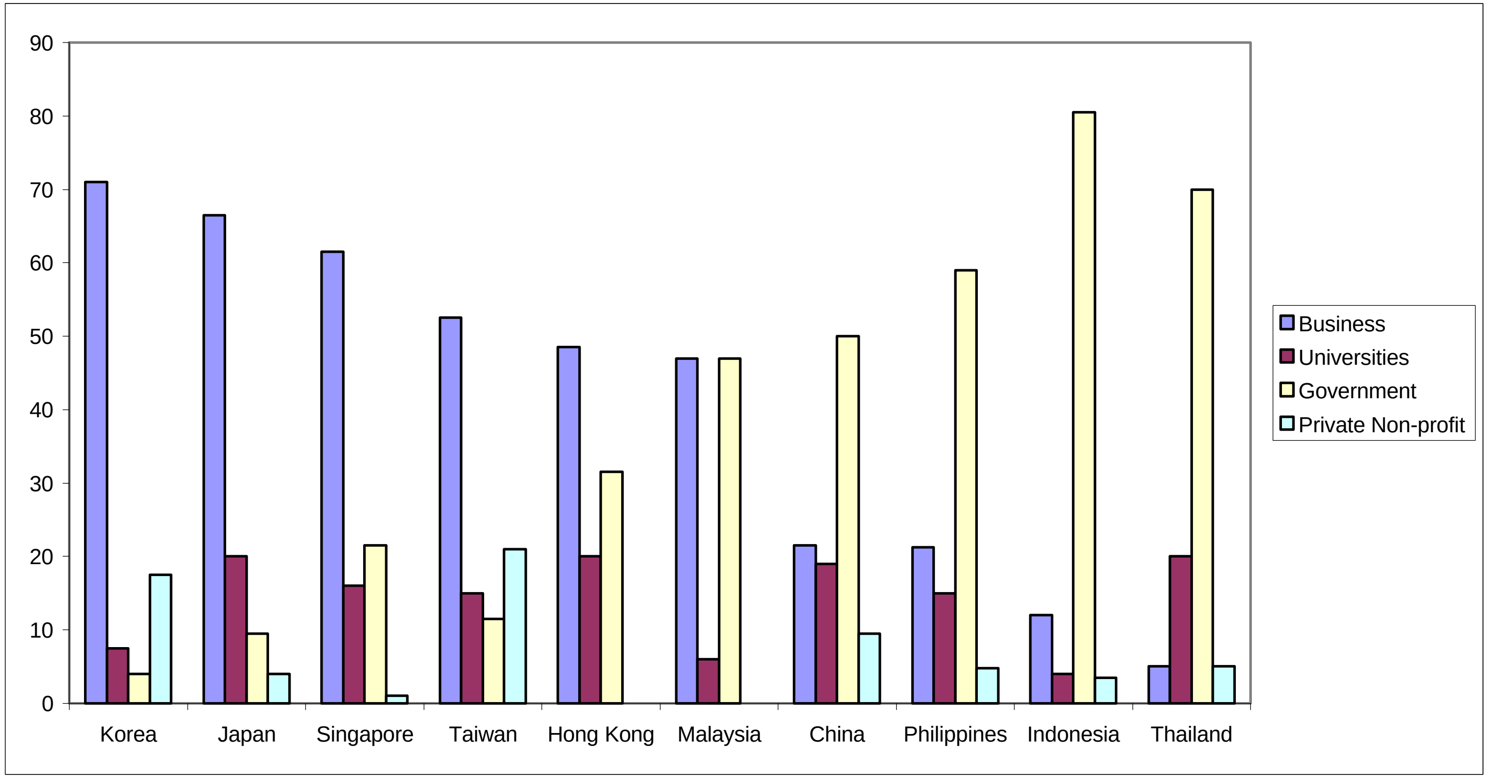

Figure IV. 6. The Overall Organizational Structure of the Science System in New Zealand

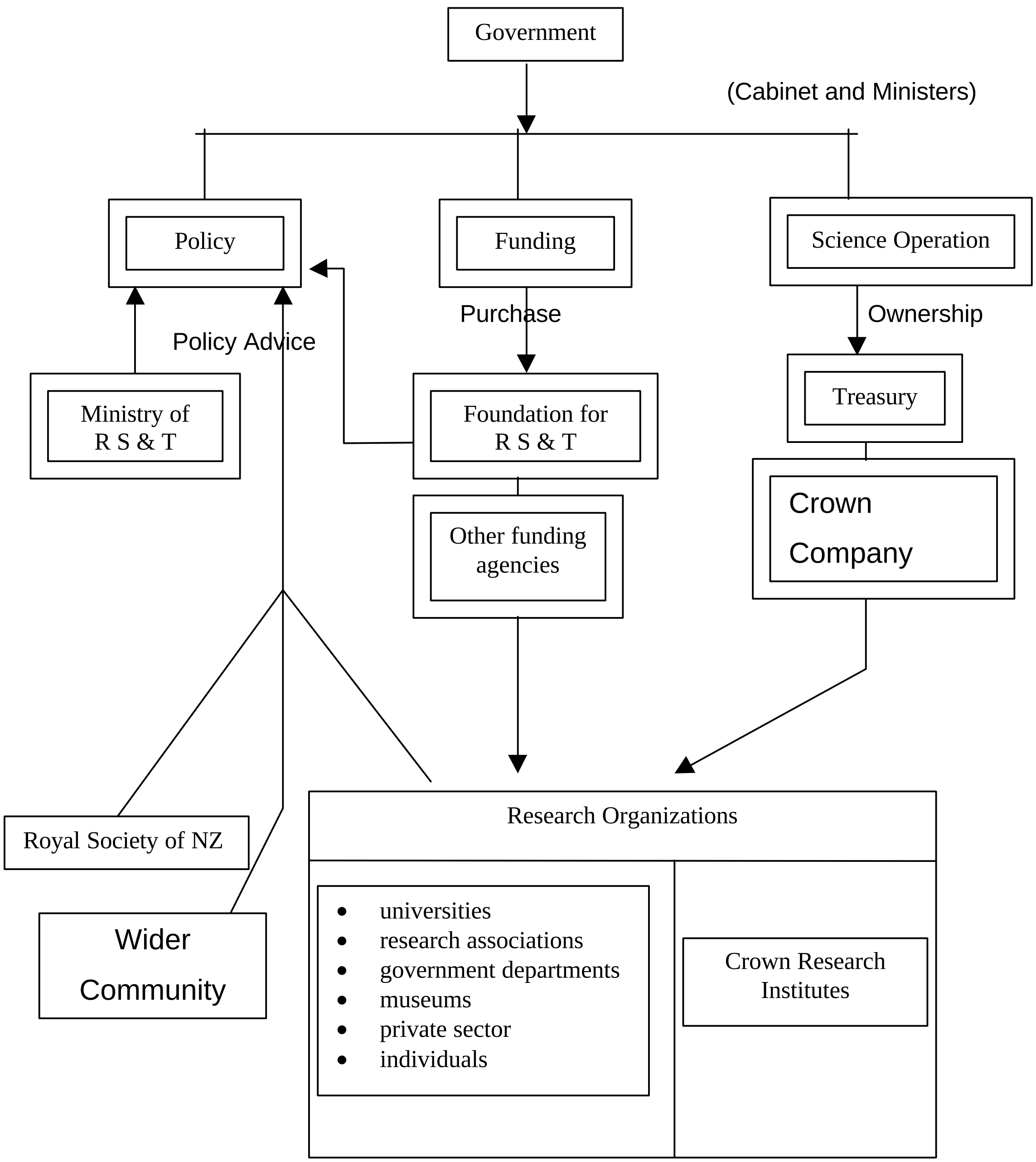

Figure IV.7. Phd Personnel (Full Time), Field of Activity (all respondents, percent distribution)

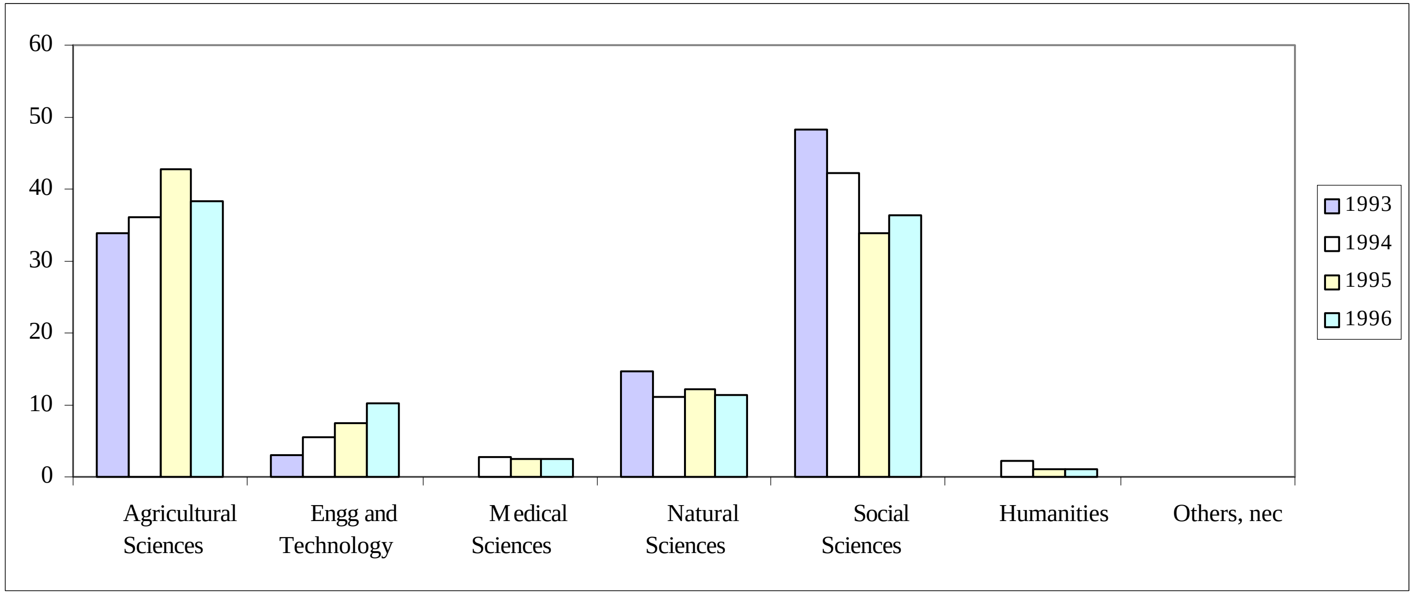

Figure IV.8. Phd Personnel (Part Time), Field of Activity (all respondents, percent distribution)

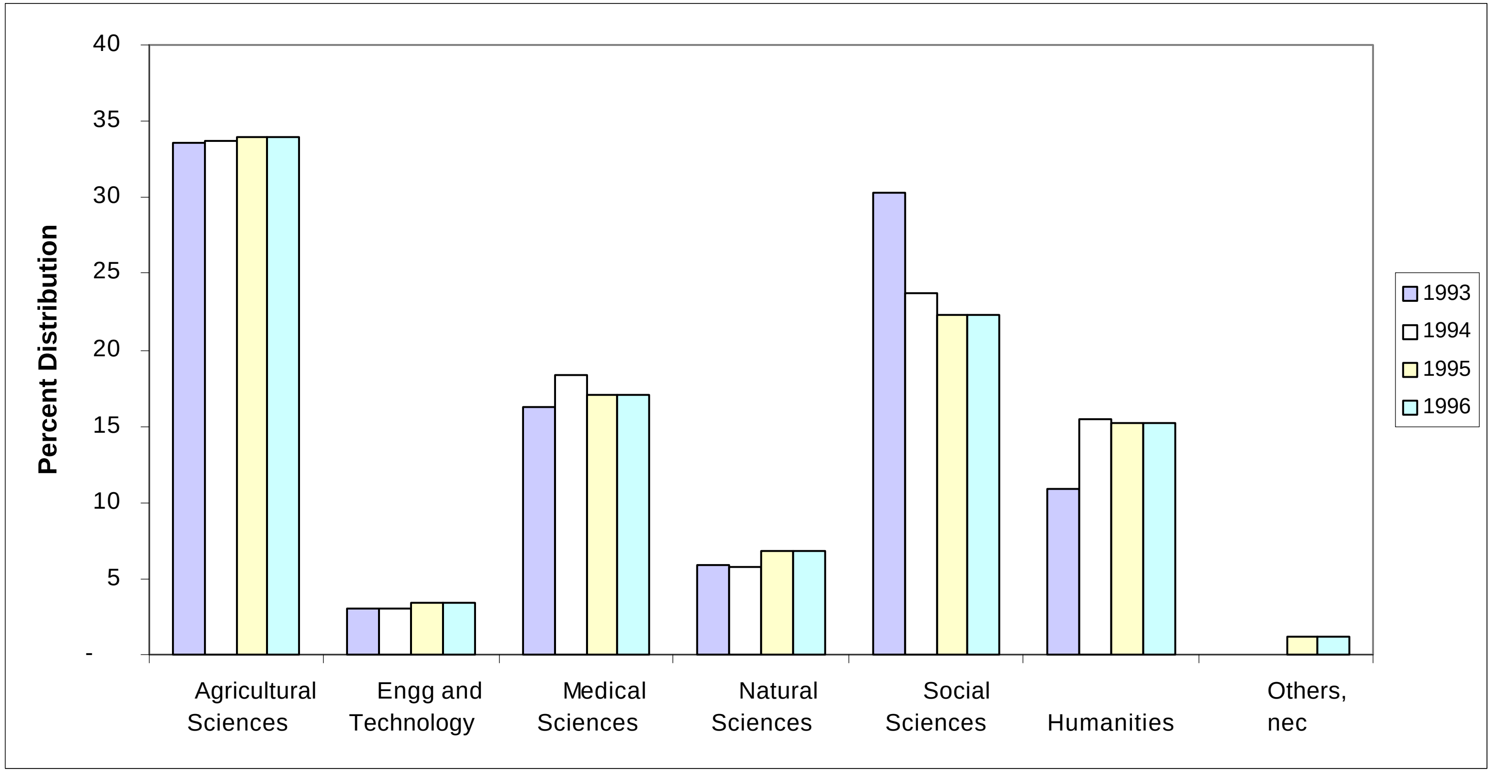

Table V.1. Distribution of the Sources of Growth in the Philippines, Various Studies (%)

Factors	Williamson (1969) 1947-55	1955-65	Sanchez (1983)* 1960-73	Patalinghug (1984) 1960-82	Austria & Martin (1992) 1950-87**
Capital	9	25	24	48	87
Labour	33	54	52	23	24
Land	3	5	n.a.	n.a.	n.a.
Education	n.a.	n.a.	n.a.	6	n.a.
TFP	55	15	24	23	-11
Total	100	100	100	100	100
GDP growth	7.3	4.5	4.6	5.5	4.6

* Sanchez (1983) decomposed the growth of the Philippines for the period 1960-73 only to use the data in comparison with Korea. TFP growth during this period was 1.1 per cent, higher than her estimates of -0.8 per cent for 1957-75.

** The output elasticities estimated from equation (5a) were multiplied by the average growth rate of capital and labour to arrive at the contribution of each factor to GDP growth. For the period 1950-87, capital and labour grew at 6.2 and 3.0 per cent, resp.

Source: Austria, Myrna & Martin, Will, Economics Division Working Papers,
Macroeconomic Instability & Growth in the Phil: a Dynamic Approach.
Research School of Pacific Studies, Australian National University, 1992.

Table V.2. Determinants of TFP Growth in Manufacturing

Variables	Coefficients	t-tests
Constant	5.316	(27.267)
Exports(-1)	0.148	(8.581)
Imports(-1)	-0.519	(-18.522)
D(Tariff)	-1.74	(-33.438)
Wage	-0.126	(-9.353)
DRD(-1)	**0.101**	**(9.353)**
FDI(-2)	0.005	(-14.081)
INF	-0.153	(-14.081)
INF(-1)	-0.468	(-23.088)
Adjusted R2	0.997	
DW	0.65	
F-Stat	448.63	

Where:
Exports(-1): real growth of exports, lagged one period
Imports(-1): real growth of imports, lagged one period
D(tariff): period differential of average nominal tariff rates
Wage: growth of research and development expenditure as % of GDP lagged one period
FDI(-2): foreign direct investment
INF: inflation
INF(-1): Inflation, lagged one period

Source: Cororaton and Abdula (1997)

Table V.3. Agricultural research intensity ratios of selected countries.

Country	RIR (%)	Reference year
Philippines	0.33	1992
Thailand	1.40	1992
Indonesia	0.27	1990
Malaysia	1.06	1992
China	0.43	1993
Taiwan	4.65	1992
Australia	3.54	1992
India	0.52	1990
Pakistan	0.47	1992
Bangladesh	0.25	1992
Sri Lanka	0.36	1993
South Korea	0.56	1993
Japan	3.36	1992
Developing countries	1.00	
Developed countries	2-3	

Source:

Philippines (this study)

Other countries: Pardey, P.G., J. Roseboom, and S. Fan (1997)

Table V.4. Distribution of public expenditures for agricultures and Natural resources by policy instruments, 1987-1994 (%).

	1987-94	1994
Agrarian Reform	26	24
Natural Resources and Environment	23	23
Agriculture	51	53
Irrigation (NIA)	12	8
Price stabilization (NFA)	9	13
Research	4	5
Extension	7	9
Coconut development	2	2
Livestock	1	2
Other	17	15

Source: David (1998)

Table V.5. Public expenditures for research and development in agriculture and natural resources, gross value added in agriculture including fishery and forestry, and research intensity ratios (RIR), 1992-1996

	1992	1993	1994	1995	1996
1. Research expenditures (₱ million)[a]					
a. w/out SEAFDEC	800	853	1,065	1,290	1,554
	(1,027)	(1,121)	(1,400)	(1,638)	(1,919)
b. with SEAFDEC	881	958	1,184	1,434	1,707
	(1,228)	(1,248)	(1,540)	(1,815)	(2,114)
2. Gross value added (₱ million)	281,748	303,415	355,612	392,954	449,080
3. Research Intensity Ratio (%)					
1a/2	0.28	0.28	0.30	0.33	0.35
	(0.36)	(0.37)	(0.39)	(0.42)	(0.43)
1b/2	0.31	0.32	0.33	0.36	0.38
	(0.40)	(0.41)	(0.43)	(0.46)	(0.47)

Note: Refers to direct budgetary outlay. Figures in parenthesis refer to total research expenditure, including external grants from local and foreign sources.

Table V.6. Public expenditures for research and development in agriculture, natural resources, and related environmental issues (In million pesos)

	1992	1993	1994	1995	1996	1997
DA[a]	459.74	464.27	651.59	758.84	913.90	na
	(500.84)	(524.46)	(695.59)	(841.89)	(1029.56)	(na)
DENR	68.98	78.60	109.69	120.80	149.33	213.97
	(84.79)	(92.76)	(123.29)	(132.87)	(160.54)	(218.30)
ERDB	23.03	21.04	15.65	15.58	21.78	64.16
	(32.35)	(29.96)	(24.15)	(22.85)	(31.78)	(65.97)
ERDS[b]	43.35	55.08	92.12	99.65	122.21	149.81
	(49.84)	(60.32)	(97.22)	(104.45)	(123.42)	(152.33)
PAWB	2.60	2.48	1.92	5.57	5.34	10.69
	(2.60)	(2.48)	(1.92)	(5.57)	(5.34)	(10.69)
DOST	81.25	100.52	103.01	153.08	180.13	228.42
	(149.62)	(159.79)	(187.96)	(216.72)	(276.71)	(378.49)
PCARRD	42.82	56.24	56.88	88.66	105.00	127.10
	(61.86)	(84.09)	(98.95)	(122.69)	(167.99)	(179.58)
PCAMRD	9.60	11.01	10.96	9.09	18.61	19.40
	(49.97)	(25.92)	(40.40)	(31.82)	(46.41)	(88.87)
FPRDI	28.83	33.27	35.16	55.33	56.53	81.93
	(37.79)	(49.78)	(48.61)	(62.21)	(62.31)	(110.04)
SCUs	189.57	209.42	200.88	257.72	309.68	331.71
	(291.63)	(343.66)	(392.80)	(446.11)	(452.01)	(495.68)
UP System	91.71	94.54	80.61	113.66	130.52	128.05
	(183.35)	(202.89)	(239.24)	(261.48)	(235.12)	(236.91)
UPLB	87.32	90.69	76.73	108.88	123.69	120.36
	(161.57)	(196.47)	(218.76)	(250.67)	(222.99)	(224.22)
UPMSI	3.70	3.70	3.15	3.97	5.67	5.79
	(na)	(na)	(na)	(na)	(na)	(na)
UPVISAYAS	0.69	0.15	0.73	0.82	1.17	1.90
	(18.08)	(2.72)	(17.33)	(6.84)	(6.46)	(6.90)
Other major univ[c]	81.98	95.88	95.53	112.57	142.97	165.84
	(92.40)	(121.78)	(128.82)	(153.14)	(180.70)	(220.95)
Other universities	15.88	18.99	24.74	31.49	36.19	37.82
	(na)	(na)	(na)	(na)	(na)	(na)
SEAFDEC	81.25	104.72	118.75	143.25	153.48	185.27
	(100.84)	(127.46)	(140.29)	(177.18)	(194.82)	(213.00)
Total w/out SEAFDEC	**799.54**	**852.81**	**1,065.17**	**1,290.44**	**1,553.04**	**na**
	(985.78)	**(1,060.48)**	**(1,355.64)**	**(1,554.54)**	**(1,918.82)**	**(na)**
Total with SEAFDEC	**880.79**	**957.53**	**1,183.92**	**1,433.69**	**1,706.52**	**na**
	(1,086.62)	**(1,187.94)**	**(1,495.93)**	**(1,731.72)**	**(2,113.64)**	**(na)**

[a] See Tables 2 & 3 for details.

[b] See Table 5 for details.

[c] See Table 9 for details.

* Refers to GAA, otherwise, it is the actual expenditure.

Note :

The numbers in parenthesis include external grants.

na = not available

Table V.7. Agency-funded fisheries R&D projects of NARRDS institutions, by number of researchers and budget, 1996

INSTITUTION	No. of Researchers	Budget (P)	Budget: Researcher Ratio
DA-BFAR	61	3,754,000	61,541
DMMMSU	13	1,072,903	82,531
UPLB	9	3,373,580	374,842
UPV	44	2,193,075	49,843
MSU-Naawan	25	1,257,125	50,285
ZSCMST	15	790,000	52,667
DA-CAR	-	230,100	-
DA-Region1	2	1,007,000	503,500
DA-Region 2	10	889,000	88,900
DA-Region 4	-	4,572,000	-
DA-Region 5	-	2,180,046	-
DA-Region 6	-	785,000	-
DA-Region 8	-	415,000	-
DA-Region 11	-	902,044	-
DA-Region 13	-	310,000	-
DA-ARMM	-	87,000	-
DENR-Region 10	-	4,165,000	-
BU	-	543,000	-
CMU	2	11,000	5,500
CSC	-	341,000	-
CSU	18	548,040	30,447
CCSPC	-	1,461,033	-
CVPC	-	244,000	-
DOSCST	-	972,500	-
ISCOF	19	2,425,000	127,632
MMSU	17	100,000	5,882
MSU-SULU	-	590,488	-
MSU-TCTO	21	1,330,000	63,333
NIPSC	3	5,450,248	1,816,749
NMP	-	64,564	-
NVSIT	5	136,000	27,200
PALSU	-	1,110,000	-
PIT	-	308,000	-
PSPC	12	25,000	2,083
PSU	8	321,000	40,125
TONC	-	60,000	-
UEP	-	496,370	-
UPMSI	25	3,579,400	143,176
Average	17	1,265,777	195,902

- means no data

Source: PCAMRD (1996a) and PCAMRD Files.

Table V.8. Agency-funded fisheries R&D projects of NARRDS institutions, by number of projects and budget, 1996

INSTITUTION	No. of Projects	Budget (P)	Budget: Project ratio
DA-BFAR	11	3,754,000	341,272.73
DMMMSU	30	1,072,903	35,763.43
UPLB	9	3,373,580	374,842.22
UPV	8	2,193,075	274,134.38
MSU-Naawan	7	1,257,125	179,589.29
ZSCMST	7	790,000	112,857.14
DA-CAR	4	230,100	57,525.00
DA-Region1	10	1,007,000	100,700.00
DA-Region 2	8	889,000	111,125.00
DA-Region 3	41	4,572,000	111,512.20
DA-Region 4	12	2,180,046	181,670.50
DA-Region 5	12	785,000	65,416.67
DA-Region 6	8	415,000	51,875.00
DA-Region 8	8	902,044	112,755.50
DA-Region 11	10	310,000	31,000.00
DA-Region 13	3	87,000	29,000.00
DA-ARMM	1	4,165,000	4,165,000.00
BU	3	543,000	181,000.00
CMU	1	11,000	11,000.00
CSC	4	341,000	85,250.00
CSU	6	548,040	91,340.00
CCSPC	4	1,461,033	365,258.25
CVPC	2	244,000	122,000.00
DOSCST	3	972,500	324,166.67
ISCOF	9	2,425,000	269,444.44
MMSU	12	100,000	8,333.33
MSU-SULU	1	590,488	590,488.00
MSU-TCTO	8	1,330,000	166,250.00
NIPSC	13	5,450,248	419,249.85
NMP	3	64,564	21,521.33
NVSIT	2	136,000	68,000.00
PALSU	4	1,110,000	277,500.00
PIT	3	308,000	102,666.67
PSPC	1	25,000	25,000.00
PSU	6	321,000	53,500.00
TONC	1	60,000	60,000.00
UEP	3	496,370	165,456.67
UPMSI	31	3,579,400	115,464.52
Total	309	48,099,516	155,661.86

- means no data

Source: PCAMRD (1996a).

Table V.9. R&D expenditures for fisheries by sector and source of funds, 1988-1994 (In million pesos)

Sector	Foreign	%	Government	%	Private Sector	%	Grand Total
Marine Fisheries	218.45	73.48	75.78	25.49	3.08	1.04	297.31
Inland Aquatic Resources	60.73	37.96	98.08	61.31	1.17	0.73	159.98
Socioeconomics	4.67	18.65	20.35	81.35	-	-	25.02
Total	283.85	58.85	194.21	40.37	4.25	0.88	482.31

Source: PCAMRD (1996a).

Table V.10. R&D expenditures for fisheries of selected NARRDS institutions, by source of external grants, 1992-1996 (In thousand pesos)

INSTITUTION	Funds	1992	1993	1994	1995	1996	Average	%
DA-BFAR	Local	0	0	200	144	1,087	286	100.00
	Foreign	0	0	0	0	0	0	0.00
	Sub-total	0	0	200	144	1,087	286	100.00
DOST-PCAMRD	Local	12,310	8,140	18,780	19,060	23,200	16,298	60.25
	Foreign	28,060	6,760	10,660	3,670	4,610	10,752	39.75
		40,370	14,900	29,440	22,730	27,810	27,050	100.00
UPV	Local	15,553	2,409	13,531	2,804	3,472	7,554	64.86
	Foreign	0	0	17,356	2,873	237	4,093	35.14
	Sub-total	15,553	2,409	30,887	5,677	3,709	11,647	100.00
Total without SEAFDEC AQD	Local	27,863	10,549	32,511	22,008	27,759	24,138	61.92
	Foreign	28,060	6,760	28,016	6,543	4,847	14,845	38.08
	Total	55,923	17,309	60,527	28,551	32,606	38,983	100.00
SEAFDEC AQD	Local	0	0	0	0	0	0	0.00
	Foreign	3,150	3,550	3,770	8,490	8,040	5,400	100.00
	Sub-total	130,009	54,269	143,484	79,357	93,639	5,400	100.00
Total with SEAFDEC AQD	Local	27,863	10,549	32,511	22,008	27,759	24,138	54.39
	Foreign	31,210	10,310	31,786	15,033	12,887	20,245	45.61
	Total	185,932	71,578	204,011	107,908	126,245	44,383	100.00

Note: MSU-Naawan has no breakdown for sources of external grants

Source: PIDS survey, 1998.

Table V.11. Distribution of manpower for fisheries R&D, by zonal areas (1996)

Agency	PhD	MS	BS	ASSOC	Total	%
Zonal Area for Northern Luzon (Region I, II. III. And CAR)	11	57	25	-	93	12.33
Zonal Area for Southern Luzon (Region NCR, IV and V)	20	45	131	12	208	27.59
Zonal Area for Visayas (Regions VI, VII and VIII)	31	117	166	6	320	42.44
Zonal Area for Northern Mindanao (Region X,XI,and Caraga)	2	19	53	-	74	9.81
Zonal Area for Southern Mindanao (Regions IX and XII)	3	21	35	-	59	7.82
TOTAL	67	259	410	18	754	100
%	8.89	34.35	54.38	2.39	100.00	

Note: Figures include SEAFDEC AQD

Source: PCAMRD (1996a).

Table V.12. Distribution of the NARRDS R&D Program budget by source of funds, 1996

COMMODITY	Source of Funds		Total
	Local (P)	Foreign (P)	Budget
Export Winners			
Seaweed	7,236,997	0	7,236,997
Crab	2,613,727	842,677	3,456,404
Tuna	225,000	0	225,000
Shrimp	1,605,739	0	1,605,739
Basic Domestic Needs			
Tilapia	2,664,975	0	2,664,975
Milkfish	80,903	0	80,903
Small Pelagics	2,257,428	0	2,257,428
Environment	29,000,173	2,262,513	31,262,686
Other Proirity Areas	14,837,104	1,500,000	16,337,104
Total	60,522,046	4,605,190	65,127,236

Source: PCAMRD (1997b).

Table V.13. Manpower for Fisheries R&D of selected NARRDS institutions, 1998

INSTITUTION	PhD	MS	BS	NI	Total
DA-BFAR	2	21	42	1	66
DOST-PCAMRD	4	11	10	0	25
DMMMSU	1	6	15	0	22
UPLB	1	1	0	0	2
UPV	0	12	13	1	26
MSU-Naawan	4	19	13	0	36
MSU-Marawi	1	15	10	1	27
CLSU	1	7	2	0	10
UPMSI	3	2	20	0	25
BU	4	9	2	0	15
MMSU	1	2	4	0	7
PSU	0	3	1	0	4
Average without SEAFDEC AQD	2	10	13	0	25
SEAFDEC	21	43	1	0	65
Average with SEAFDEC AQD	1	7	7	0	15

Note: NI means not indicated

Source: PIDS Survey, 1998.

Table V.14. Comparison of the number of R & D personnel in selected NARRDS and NARRDN institutions, 1995-1996

INSTITUTION	PhD	MS	BS	Total	Graduate:Undergraduate
NARRDS					
UPLB	4	3	2	9	3.50
DMMMSU	1	9	3	13	3.33
UPV	15	13	16	44	1.75
MSU-NAAWAN	2	14	9	25	1.78
CLSU	1	10	0	11	0.00
UPMSI	15	6	4	25	5.25
ZSCMST	3	7	5	15	2.00
Average	5	9	6	18	2.52
NARRDN					
UPLB	53	206	225	484	1.15
USM	37	72	8	117	13.63
ViSCA	39	69	24	132	4.50
BSU	15	36	36	87	1.42
CMU	43	135	139	317	1.28
ISU	17	61	13	91	6.00
CSSAC	19	40	30	89	1.97
Average	32	88	68	188	4.28

Note: NARRDN stands for National Agriculture and Natural Resources Research and Development Network, the counterpart of NARRDS. NARRDS data are for 1996 while NARRDN data are for 1995. NARRDS data are specifically for fisheries R&D manpower only.

Sources: PCAMRD (1996a) and RMC,CEM-UPLB (1997).

Table V.15. R&D expenditures for fisheries, GNP and GVA of the Philippines, 1982-1995 (In million pesos)							
		Gross Value Added (GVA)			R & D as % of		
		Gross	Agriculture/		Gross	Gross Gross Value Added (GVA)	
	R&D	National	Forestry/	Fisheries	National		
	Expenditure	Product	Fisheries		Product	Agri./ For./	Fisheries
Year	in Fishery	(GNP)			(GNP)	Fisheries	
1982	14.52	313,544	74,055	14,084	0.005	0.020	0.103
1983	14.67	363,268	82,545	17,580	0.004	0.018	0.083
1984	10.14	508,485	129,824	22,666	0.002	0.008	0.045
1985	15.82	556,074	140,554	27,058	0.003	0.011	0.058
1986	22.02	596,276	145,807	32,019	0.004	0.015	0.069
1987	18.07	673,130	163,927	31,256	0.003	0.011	0.058
1988	33.40	792,012	183,515	34,708	0.004	0.018	0.096
1989	37.03	912,027	210,009	36,460	0.004	0.018	0.102
1990	76.33	1,082,557	235,956	40,833	0.007	0.032	0.187
1991	67.74	1,266,070	261,868	47,276	0.005	0.026	0.143
1992	109.98	1,385,562	294,922	51,633	0.008	0.037	0.213
1993	119.49	1,500,287	318,546	57,533	0.008	0.038	0.208
1994	38.34	1,737,315	372,853	65,860	0.002	0.010	0.058
1995	63.89	1,970,519	412,965	70,206	0.003	0.015	0.091
Average	45.82	975,509	216,239	39,227	0.004	0.019	0.102

Source of Table: PCAMRD (1996a).

Table V.16. Tertiary Education Across Selected Pacific Rim Countries

Country/Year		(1)	(2)	(3)	(4)	(5)	(6)
China	(1991)	2,124,121	0.17	80,459	3.79	59,748	74.26
Japan	(1989)	2,683,035	2.13	85,263	3.18	54,167	63.53
South Korea	(1991)	1,723,886	3.83	92,599	5.37	28,479	30.76
Australia	(1991)	534,538	2.92	92,903	17.38	26,876	28.93
Singapore	(1983)	35,192	1.13	1,869	5.31	532	28.46
Malaysia	(1990)	121,412	0.58	4,981	4.1	1,251	25.12
Thailand	(1989)	765,395	1.24	21,044	2.75	4,928	23.42
New Zealand	(1991)	136,332	3.78	13,792	10.12	2,863	20.76
Philippines	(1991)	1,656,815	2.39	63,794	3.85	5,520	8.65

Column Definition:
(1) : Number of students at tertiary level
(2) : Number tertiary students as percent of population
(3) : Number of post-baccalaureate students
(4) : Post-baccalaureate as % of Tertiary Students
(5) : Number of post-baccalaureate science & engineering students
(6) : Post-baccalaureate science & engineering as percent of post-baccalaureate students
Source: Basic source of data UNESCO World Science Report (1996).

Figure V.1. Phd Personnel (Full Time), Field of Activity (all respondents, percent distribution)

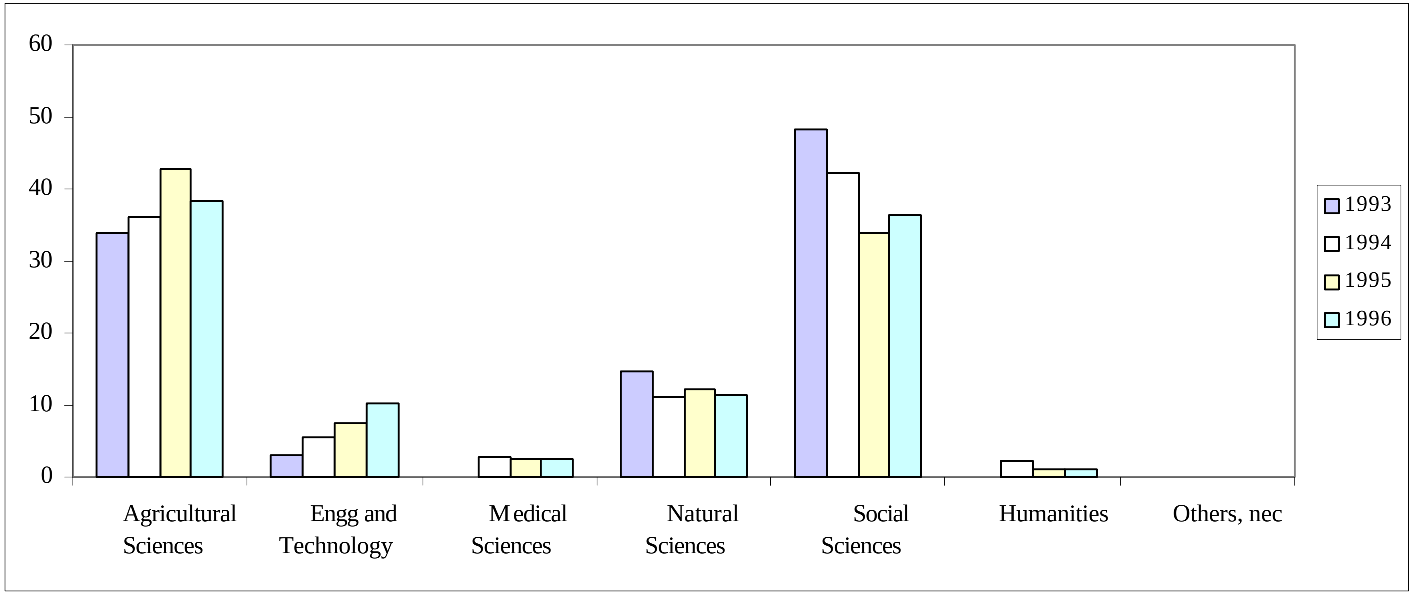

Figure V.2. Phd Personnel (Part Time), Field of Activity (all respondents, percent distribution)